AD-A162 364

INSTALLATION RESTORATION PROGRAM
PHASE I: RECORDS SEARCH
F.E. WARREN AFB
WYOMING

Prepared For

United States Air Force
STRATEGIC AIR COMMAND
Deputy Chief of Staff
Engineering and Services
Offutt AFB, Nebraska 68113

September 1985

Prepared By

ENGINEERING-SCIENCE
57 Executive Park South, Suite 590
Atlanta, Georgia 30329

TABLE OF CONTENTS

		Page
	LIST OF FIGURES	iii
	LIST OF TABLES	iv
	EXECUTIVE SUMMARY	-1-
SECTION 1	INTRODUCTION	
	Background and Authority	1-1
	Purpose and Scope	1-2
	Methodology	1-5
SECTION 2	INSTALLATION DESCRIPTION	
	Base History	2-1
	Organization and Mission	2-7
SECTION 3	ENVIRONMENTAL SETTING	
	Climate	3-1
	Geography and Topography	3-3
	Drainage	3-3
	Surface Soils	3-5
	Geology	3-5
	Stratigraphy	3-9
	Distribution	3-9
	Structure	3-9
	Hydrology	3-13
	High Plains Aquifer	3-13
	Water Use and Water Quality	3-15
	Threatened and Endangered Species	3-21
	Environmental Summary	3-21
SECTION 4	FINDINGS	
	Installation Hazardous Waste Activity Review	4-1
	Industrial Operations (Shops)	4-2
	Waste Accumulation and Storage Areas	4-9
	Pesticide Utilization	4-9
	Fuels Management	4-11
	Spills and Leaks	4-11
	Fire Protection Training	4-14
	Installation Waste Disposal Methods	4-16
	Landfills	4-16
	Hardfill Disposal Areas	4-20
	Sanitary Sewerage System	4-20
	Explosive Ordnance Disposal Area	4-20
	Acid Dry Well	4-24

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE

REPORT DOCUMENTATION PAGE

1a. REPORT SECURITY CLASSIFICATION Unclassified	1b. RESTRICTIVE MARKINGS
2a. SECURITY CLASSIFICATION AUTHORITY N/A	3. DISTRIBUTION/AVAILABILITY OF REPORT This document has been approved for public release and sale; its distribution is unlimited.
2b. DECLASSIFICATION/DOWNGRADING SCHEDULE N/A	
4. PERFORMING ORGANIZATION REPORT NUMBER(S) N/A	5. MONITORING ORGANIZATION REPORT NUMBER(S) F E Warren - I - Sep 85
6a. NAME OF PERFORMING ORGANIZATION Engineering-Science 6b. OFFICE SYMBOL (If applicable) N/A	7a. NAME OF MONITORING ORGANIZATION HQ AFESC/DEVP
6c. ADDRESS (City, State and ZIP Code) 57 Executive Park S., N.E., Suite 590 Atlanta GA 30329	7b. ADDRESS (City, State and ZIP Code) Tyndall AFB FL 32403
8a. NAME OF FUNDING/SPONSORING ORGANIZATION HQ SAC 8b. OFFICE SYMBOL (If applicable) DEPVQ	9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER F 08637 84 C0070
8c. ADDRESS (City, State and ZIP Code) Offutt AFB NE 68113	10. SOURCE OF FUNDING NOS. PROGRAM ELEMENT NO. / PROJECT NO. / TASK NO. / WORK UNIT NO.
11. TITLE (Include Security Classification) See block 19	

12. PERSONAL AUTHOR(S)
Schroeder, E.J., Palumbo, D.A., Stephens, R.D., McAuliffe, J.P.

13a. TYPE OF REPORT	13b. TIME COVERED	14. DATE OF REPORT (Yr., Mo., Day)	15. PAGE COUNT
Final	FROM N/A TO	September 1985	234

16. SUPPLEMENTARY NOTATION
AFESC Project Officer: Capt Jose R. Correa

17. COSATI CODES		
FIELD	GROUP	SUB. GR.

18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)
Installation Restoration Program; Hazardous Waste Management; Past Solid Waste Disposal Sites; IRP Phase I; F E Warren AFB

19. ABSTRACT (Continue on reverse if necessary and identify by block number)

11. Title: Phase I - Records Search Installation Restoration Program - F E Warren AFB.

This report identified and evaluated several potentially hazardous waste disposal sites at F E Warren AFB. Records of past waste handling and disposal practices were reviewed. Interviews with past and present installation employees were conducted to develop a history of waste disposal practices. The environmental setting was evaluated including soils, geology, groundwater, and surface water. Five landfills, six spill sites, two fire protection training areas and an acid dry well were found to have sufficient potential to create environmental contamination and follow-on investigations (Phase II) were recommended and outlined.

20. DISTRIBUTION/AVAILABILITY OF ABSTRACT UNCLASSIFIED/UNLIMITED ☒ SAME AS RPT. ☐ DTIC USERS ☐	21. ABSTRACT SECURITY CLASSIFICATION Unclassified

22a. NAME OF RESPONSIBLE INDIVIDUAL	22b. TELEPHONE NUMBER (Include Area Code)	22c. OFFICE SYMBOL
Capt Charles R Howell	AV 271-5854 (402) 294-5854	HQ SAC/DEPVQ

DD FORM 1473, 83 APR EDITION OF 1 JAN 73 IS OBSOLETE.

SECURITY CLASSIFICATION OF THIS PAGE

TABLE OF CONTENTS
(Continued)

		Page
	Satellite Facilities Review	4-24
	Microwave Relay Station	4-24
	Missile Sites	4-24
	Evaluation of Past Disposal Activities and Facilities	4-26
	Sites Eliminated From Futher Evaluation	4-27
	Sites Evaluated Using HARM	4-29
SECTION 5	CONCLUSIONS	
	Spill Site No. 4	5-1
	Landfill No. 4	5-3
	Landfill No. 6	5-3
	Landfill No. 5	5-4
	Landfill No. 2	5-4
	Spill Site No. 1	5-4
	Fire Protection Training Area No. 2	5-5
	Spill Site No. 2	5-5
	Acid Dry Well	5-6
	Fire Protection Training Area No. 1	5-6
	Landfill No. 3	5-7
	Spill Site No. 3	5-7
	Spill Site No. 5	5-7
	Spill Site No. 6	5-8
SECTION 6	RECOMMENDATIONS	
	Monitoring Rationale	6-1
	Recommended Phase II Monitoring	6-4
	Spill Site No. 4	6-4
	Landfill No. 4	6-9
	Landfill No. 6	6-9
	Landfill No. 5	6-9
	Landfill No. 2	6-10
	Spill Site No. 1	6-10
	Fire Protection Training No. 2	6-10
	Spill Site No. 2	6-10
	Acid Dry Well	6-11
	Fire Protection Training Area No. 1	6-11
	Landfill No. 3	6-12
	Spill Site No. 3	6-12
	Spill Site No. 5	6-12
	Spill Site No. 6	6-12

TABLE OF CONTENTS
(Continued)

APPENDIX A	BIOGRAPHICAL DATA
APPENDIX B	LIST OF INTERVIEWEES AND OUTSIDE AGENCY CONTACTS
APPENDIX C	TENANT ORGANIZATIONS AND MISSIONS
APPENDIX D	SUPPLEMENTAL BASE FINDINGS INFORMATION
APPENDIX E	MASTER LIST OF SHOPS
APPENDIX F	PHOTOGRAPHS
APPENDIX G	USAF INSTALLATION RESTORATION PROGRAM HAZARD ASSESSMENT RATING METHODOLOGY
APPENDIX H	SITE HAZARD ASSESSMENT RATING FORMS
APPENDIX I	GLOSSARY OF TEMINOLOGY AND ABBREVIATIONS
APPENDIX J	REFERENCES
APPENDIX K	INDEX OF REFERENCES TO POTENTIAL CONTAMINATION SITES AT WARREN AFB

LIST OF FIGURES

No.	Title	Page
1	Sites of Potential Environmental Contamination	-4-
1.1	U.S. Air Force Installation Restoration Program	1-3
1.2	Records Search Flow Chart	1-7
2.1	Area Location	2-2
2.2	Regional Location	2-3
2.3	Installation Site Plan - South	2-4
2.4	Installation Site Plan - North	2-5
2.5	Missile Flights	2-6
3.1	Regional Physiographic Divisions	3-4
3.2	Surface Drainage	3-6
3.3	Soils Map	3-7
3.4	Surficial Geologic Map	3-11
3.5	Generalized Geologic Cross-Sections	3-12
3.6	Generalized Shallow Stratigraphy of Ogallala Formation	3-14
3.7	Irrigation and Municipal Well Locations	3-16
3.8	Regional Ground-Water Flow in the High Plains Aquifer	3-17
3.9	Water Level Decline of High Plains Aquifer 1920-1987	3-19
3.10	Surface Water Sampling Locations	3-20
4.1	Spill Sites	4-12
4.2	Fire Protection Training Area Sites	4-15
4.3	Landfill Sites	4-17
4.4	Hardfill Sites	4-21
4.5	Sewage Treatment Plant Site	4-22

LIST OF FIGURES
(Continued)

No.	Title	Page
4.6	EOD Area	4-23
4.7	Acid Dry Well	4-25
6.1	Sites of Potential Environmental Contamination	6-2

LIST OF TABLES

No.	Title	Page
1	Sites Evaluated Using the Hazard Assessment Rating Methodology	-5-
2	Recommended Monitoring Program for Phase II IRP at F.E. Warren AFB	-7-
3.1	Climatic Conditions at F.E. Warren AFB	3-2
3.2	F.E. Warren Air Force Base Soils	3-8
3.3	Geologic and Hydrogeologic Units	3-10
4.1	Industrial Operations (Shops)	4-4
4.2	Waste Accumulation and Storage Areas	4-10
4.3	Summary of Landfill Disposal Sites	4-18
4.4	Summary of Flow Chart Logic for Areas of Initial Health, Welfare and Environmental Concern at F.E. Warren AFB	4-28
4.5	Summary of HARM Scores for Potential Contamination Sites at F.E. Warren AFB	4-30
5.1	Sites Evaluated Using the Hazard Assessment Rating Methodology	5-2
6.1	Recommended Monitoring Program for Phase II IRP at F.E. Warren AFB	6-5
6.2	Recommended List of Analytical Parameters for Phase II IRP at F.E. Warren AFB	6-8

EXECUTIVE SUMMARY

The Department of Defense (DOD) has developed a program to identify and evaluate past hazardous material disposal sites on DOD property, to control the migration of hazardous contaminants, and to control hazards to health or welfare that may result from these past disposal operations. This program is called the Installation Restoration Program (IRP). The IRP has four phases consisting of Phase I, Installation Assessment/Records Search; Phase II, Confirmation/Quantification; Phase III, Technology Base Development; and Phase IV, Operations/Remedial Actions. Engineering-Science was retained by the United States Air Force to conduct the Phase I, Initial Assessment/Records Search for F. E. Warren Air Force Base (AFB) under Contract No. F0863784 R00 40.

INSTALLATION DESCRIPTION

F. E. Warren AFB is located in southeastern Wyoming on the west side of Cheyenne. The base is located 10 miles North of the Colorado border, and 40 miles West of the Nebraska state line. The main base consists of approximately 5,866 acres, and is bordered by agricultural or undeveloped residential land to the north, south and west and the City of Cheyenne on the east. Remote installation facilities include a quarter acre microwave relay station and the 90th Strategic Missile Wing (SMW) Sites comprising 26,953 acres. The 90th SMW Sites consist of 20 Minuteman III Intercontinental Ballistic Missile (ICBM) Launch Conrol Facilities (LCFs) and 200 Minuteman III ICBM Launch Facilities (LFs) located in Wyoming, Nebraska, and Colorado.

The base became a part of the Air Force System in 1947 and occupies an historic federal installation with its beginning in the last century. The base began as an army outpost in 1867 and was named Fort D. A. Russell. In 1930 the name was changed to Fort Francis E. Warren. The Fort was transfered to the Air Force in 1947 and served as a TAC Training Facility until 1958. In 1958 SAC assumed command, and F. E.

Warren AFB was selected as the first host base for the Atlas Missiles. Between October, 1962 and July, 1965 the Minuteman Missiles were deployed from F. E. Warren AFB, and the Atlas Missiles were deactivated. The 90th Strategic Missile Wing became the host unit in 1963 and has retained that position to today.

ENVIRONMENTAL SETTING

The environmental setting data reviewed for this investigation identified the following points relevant to F. E. Warren AFB:

- An important, extensively used aquifer, the High Plains aquifer, underlies F. E. Warren AFB. The top of the aquifer or the water level surface lies within 10 feet of the surface within some areas of the base. Because the aquifer is heterogeneous, lenses of sand and gravel or permeable zones can exist at any depth up to 500 or 600 feet beneath the surface. The base is in an area which recharges to the High Plains aquifer by direct precipitation and also through stream leakage in some areas and at times of the year.
- The High Plains aquifer is used extensively for irrigation, municipal, and domestic supply wells which surround the base. The residences along Roundup and Happy Jack Road have private supply wells and the City of Cheyenne municipal supply wellfield is located within 3 miles of the base.
- Crow Creek flows through the base in a northwest to southeast direction.
- Base surficial soils are predominantly sands and gravels that exhibit relatively high permeabilities.
- Annual net precipitation for the area is minus 43 inches. This condition reduces the potential volume of leachate generation resulting from precipitation at landfills located on F. E. Warren AFB.
- No wetlands exist at F. E. Warren AFB.

- The larger of the two known remaining populations of the Colorado butterfly plant, which is on the Wyoming Endangered Species list, exist in the moist meadow along Crow and Diamond Creeks and the unnamed drainage south of the Weapons Storage Area.

METHODOLOGY

During the course of this project, interviews were conducted with installation personnel (past and present) familiar with past waste disposal practices; file searches were performed for past hazardous waste activities; interviews were held with local, state and federal agencies; and field surveys were conducted at suspected past hazardous waste activity sites.

FINDINGS AND CONCLUSIONS

Fourteen sites (Figure 1) were identified as potentially containing hazardous contaminants and having the potential for contaminant migration resulting from past activities. These sites have been assessed using a Hazard Assessment Rating Methodology (HARM) which takes into account factors such as site characteristics, waste characteristics, potential for contaminant migration and waste management practices. The rating system is designed to indicate the relative need for follow-up investigation. The results of the HARM assessment are given in Table 1.

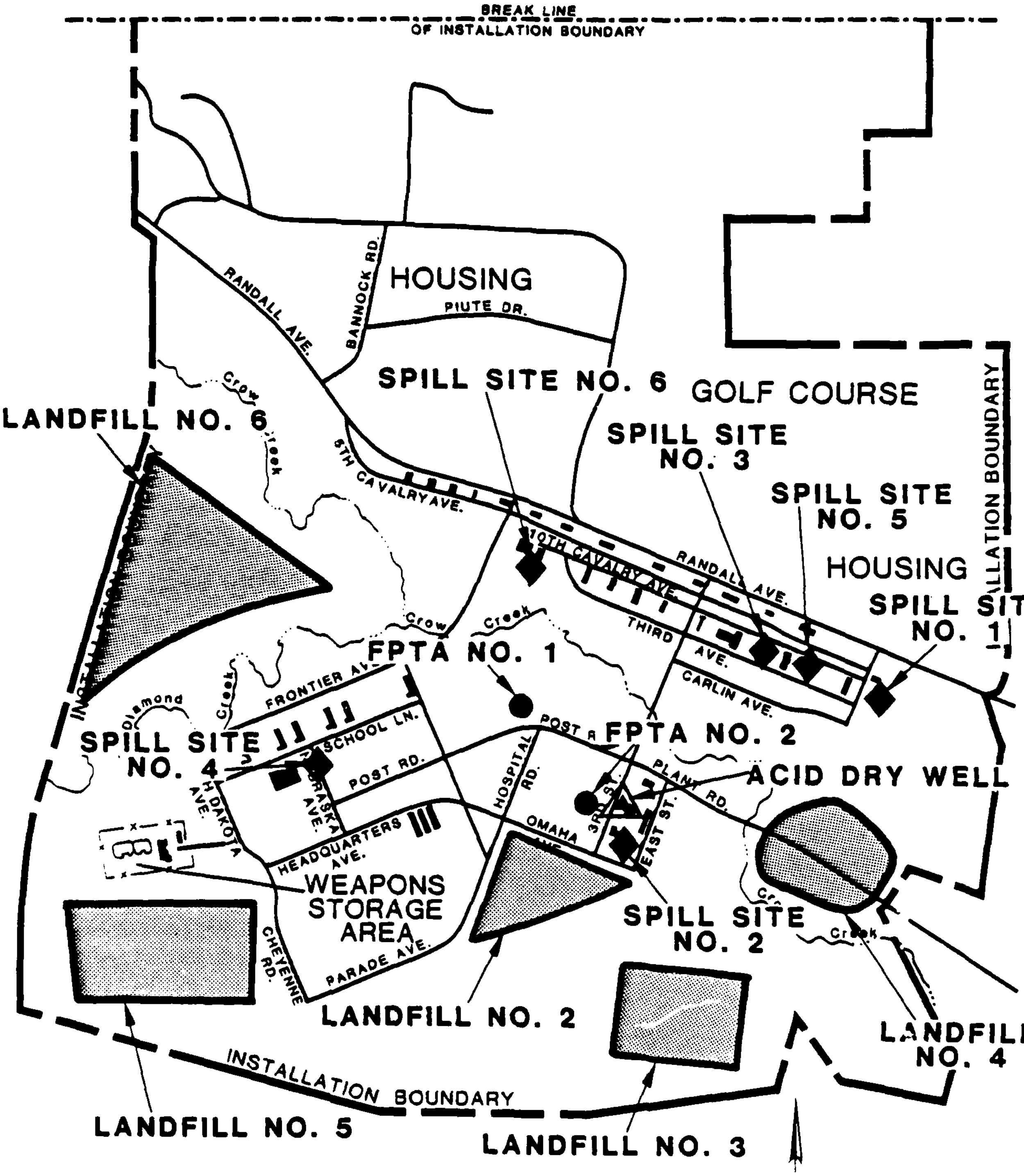
RECOMMENDATIONS

A program for proceeding with Phase II and other IRP activities at F. E. Warren AFB is recommended. This program may be expanded to define the extent and type of contamination if the initial step reveals contamination. The Phase II recommendations are summarized below:

- Spill Site No. 4 (Building 250, TCE Spill). Install two deep wells to determine the vertical extent of contamination, and conduct test borings to aid in locating the specific source.

F.E. WARREN AFB

SITES OF POTENTIAL ENVIRONMENTAL CONTAMINATION



NOTE: THE NORTH SECTION OF THE BASE CONTAINED NO SITES OF POTENTIAL CONTAMINATION.

SOURCE: INSTALLATION DOCUMENTS

TABLE 1
SITES EVALUATED USING THE
HAZARD ASSESSMENT RATING METHODOLOGY
F.E. WARREN AFB

Rank	Site	Operation Period	HARM Score (1)
1	Spill Site No. 4 (Building No. 1250)	1982	83
2	Landfill No. 4	1947-1959	75
3	Landfill No. 6	1971-Present	74
4	Landfill No. 5	1960-1970	66
5	Landfill No. 2	1900-1941	65
6	Spill Site No. 1 (Building No. 400)	1973	62
7	Fire Protection Training Area No. 2	1965-Present	60
8	Spill Site No. 2 (Building No. 810)	1983	60
9	Acid Dry Well	Mid 1960's-Present	60
10	Fire Protection Training Area No. 1	1950-1965	57
11	Landfill No. 3	1941-1947	56
12	Spill Site. No. 3 (Building No. 338)	1980	53
13	Spill Site No. 5 (Building No. 336)	1962-Present	53
14	Spill Site No. 6 (Building No. 316)	1962-Present	53

(1) This ranking was performed according to the Hazard Assessment Rating Methodology (HARM) described in Appendix G. Individual rating forms are in Appendix H.

- Landfill No. 4. Use geophysics to determine the landfill extent. Install and sample one upgradient and three downgradient wells.
- Landfill No. 6. Use geophysics to determine the landfill extent. Install and sample one upgradient and four downgradient wells.
- Landfill No. 5. Use geophysics to determine the landfill extent. Install and sample one upgradient and three downgradient wells.
- Landfill No. 2. Use geophysics to determine the landfill extent. Install and sample one upgradient and three downgradient wells.
- Spill Site No. 1 (Building 400, Service Station). Install and sample one upgradient and three downgradient wells.
- Fire Protection Training Area No. 2. Perform three soil borings to 20 feet with sampling at two foot intervals.
- Spill Site No. 2 (Building 810 Accumulation Point). Perform five soil borings to 20 feet with sampling at two-foot intervals.
- Acid Dry Well (Building 826). Use geophysics to determine the extent of the spill and perform three soil borings to 20 feet with sampling at two-foot intervals.
- Fire Protection Training Area No. 1. Perform three soil borings to 20 feet with sampling at two-foot intervals.
- Landfill No. 3. Use geophysics to determine the landfill extent. Install and sample one upgradient and three downgradient wells.
- Spill Site No. 3 (Building 338, Acid Spill). Use geophysics to determine the extent of the spill and perform two borings to 20 feet with sampling at two-foot intervals.
- Spill Site No. 5 (Building 336, Accumulation Point). Perform two soil borings to 20 feet with sampling at two-foot intervals.
- Spill Site No. 6 (Building 316, Accumulation Point). Perform four soil borings to 20 feet with sampling at two-foot intervals.

SECTION 1

INTRODUCTION

BACKGROUND AND AUTHORITY

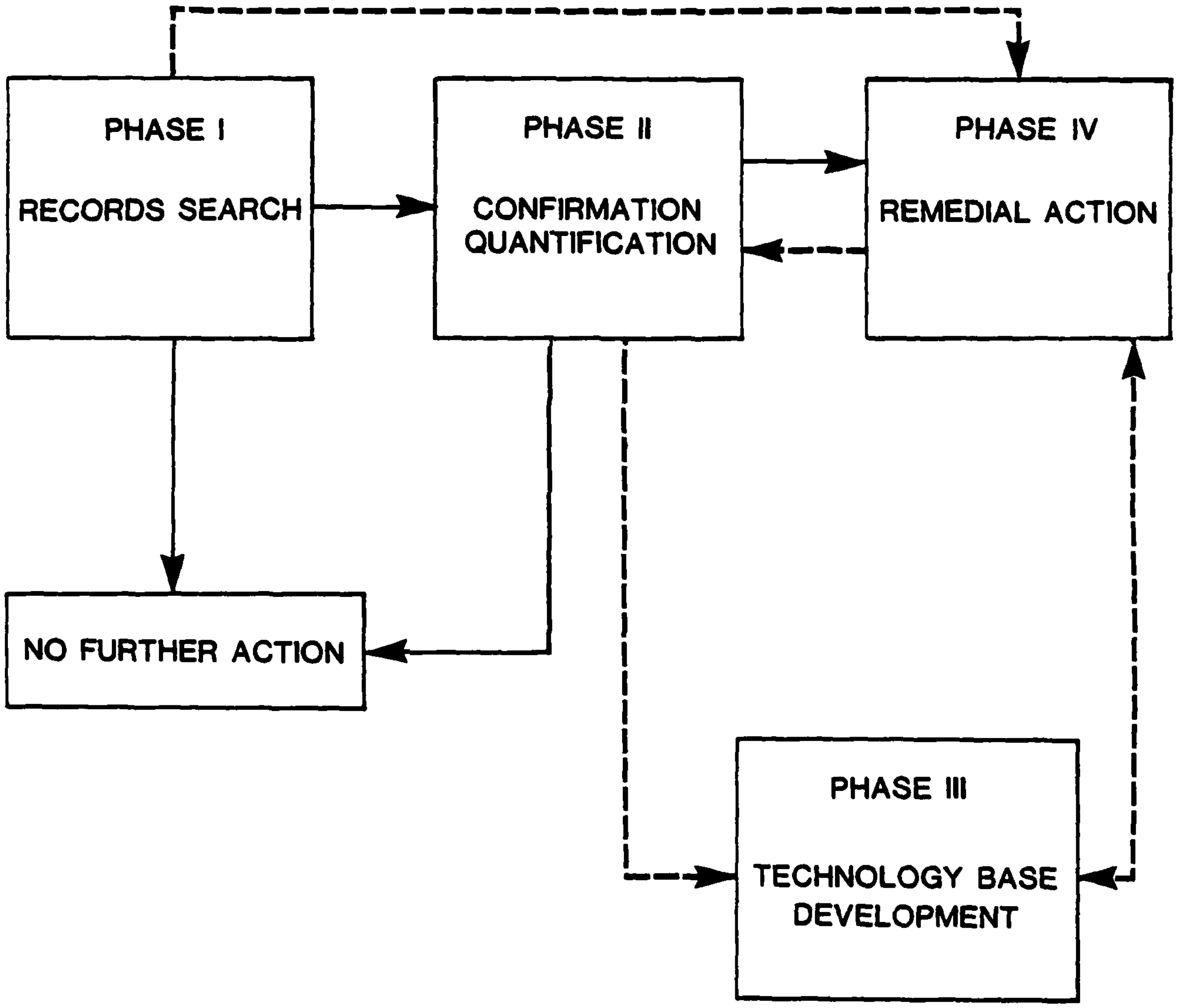
The United States Air Force, due to its primary mission of defense of the United States, has long been engaged in a wide variety of operations dealing with toxic and hazardous materials. Federal, state, and local governments have developed regulations that require disposers of waste to identify the locations and contents of past disposal sites and take action to eliminate hazards in an environmentally responsible manner. The primary Federal legislation governing disposal of hazardous waste is the Resource Conservation and Recovery Act (RCRA) of 1976, as amended. Under Section 6003 of the Act, Federal agencies are directed to assist the Environmental Protection Agency (EPA) and under Section 3012, state agencies are required to inventory past disposal sites, and Federal agencies are required to make the information available to the requesting agencies. To assure compliance with these hazardous waste regulations, the Department of Defense (DOD) developed the Installation Restoration Program (IRP). The current DOD IRP policy is contained in Defense Environmental Quality Program Policy Memorandum (DEQPPM) 81-5, dated 11 December 1981 and implemented by Air Force message dated 21 January 1982. DEQPPM 81-5 reissued and amplified all previous directives and memoranda on the Installation Restoration Program. DOD policy is to identify and fully evaluate suspected problems associated with past disposal practices of hazardous waste and resulting contamination, and to control hazards to health and welfare that resulted from these past practices. The IRP is the basis for response actions on Air Force installations under the provisions of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980, clarified by Executive Order 12316. CERCLA is the primary legislation governing remedial action at past hazardous waste disposal sites.

PURPOSE AND SCOPE

The IRP is a four-phased program (Figure 1.1) designed to assure that identification, confirmation/ quantification, and remedial actions are performed in a timely and cost-effective manner. Each phase is briefly described below:

- Phase I - Installation Assessment/Records Search - The purpose of Phase I is to identify and prioritize those past disposal sites that may pose a hazard to public health or the environment as a result of contaminant migration to surface or ground waters, or have an adverse effect by its persistence in the environment. In this phase it is determined whether a site requires further action to confirm an environmental hazard or whether it may be considered to present no hazard. If a site requires immediate remedial action, such as removal of abandoned drums, the action can proceed directly to Phase IV. Phase I is a basic background document for the Phase II study.
- Phase II - Confirmation/Quantification - The purpose of Phase II is to determine and quantify, by preliminary and comprehensive environmental and/or ecological survey, the presence or absence of contamination, the extent of contamination, waste characterization (when required by the regulatory agency), and to identify sites or locations where remedial action is required in Phase IV. Research requirements identified during this phase will be included in the Phase III effort of the program.
- Phase III - Technology Base Development - The purpose of Phase III is to develop a sound data base upon which to prepare a comprehensive remedial action plan. This phase includes implementation of research requirements and technology for objective assessment of adverse effects. A Phase III requirement can be identified at any time during the program.
- Phase IV - Operations/Remedial Actions - Phase IV includes the preparation and implementation of the remedial action plan.

U.S. AIR FORCE INSTALLATION RESTORATION PROGRAM



SOURCE: AFESC

Engineering-Science was retained by the United States Air Force to conduct the Phase I Records Search at F.E. Warren Air Force Base (AFB) under Contract No. F0863784 R00 40. This report contains a summary and an evaluation of the information collected during Phase I of the IRP and recommended follow-on actions. The approximate land area included as part of the F.E. Warren AFB study is as follows:

F. E. Warren AFB	5866 Acres
Microwave Relay Station	1/4 Acre
Minute Man III Missile Sites	26,953 Acres

The activities performed as a part of the Phase I study scope included the following:

- Review of site records
- Interviews with personnel familiar with past generation and disposal activities
- Survey of types and quantities of wastes generated
- Determination of current and past hazardous waste treatment, storage, and disposal activities
- Description of the environmental setting at the base
- Review of past disposal practices and methods
- Reconnaissance of field conditions
- Collection of pertinent information from federal, state and local agencies
- Assessment of the potential for contaminant migration
- Development of recommendations for follow-on actions

Engineering-Science performed the on-site portion of the records search during May 6-10, 1985. The following team of professionals were involved:

E. J. Schroeder, P.E., Environmental Engineer and Project Manager, 18 years experience.

D. A. Palombo, C.P.G., Hydrogeologist, 11 years of professional experience.

R. D. Stephens, Environmental Scientist, 14 years of professional experience.

J. P. McAuliffe, Environmental Engineer, 3 years of professional experience.

More detailed information on these four individuals is presented in Appendix A.

METHODOLOGY

The methodology utilized in the F. E. Warren AFB Records Search began with a review of past and present industrial operations conducted at the installation. Information was obtained from available records such as shop files and real property files, as well as interviews with 67 past and present base employees from various operating areas. Those interviewed included current and past personnel associated with civil engineering, fuels management, roads and grounds maintenance, fire protection, real property, history, and local citizens with knowledge of previous uses of current base property. A listing of interviewee positions with approximate years of service is presented in Appendix B.

Concurrent with the employee interviews, the applicable federal, state and local agencies were contacted for pertinent study area related environmental data. The agencies contacted are listed in Appendix B.

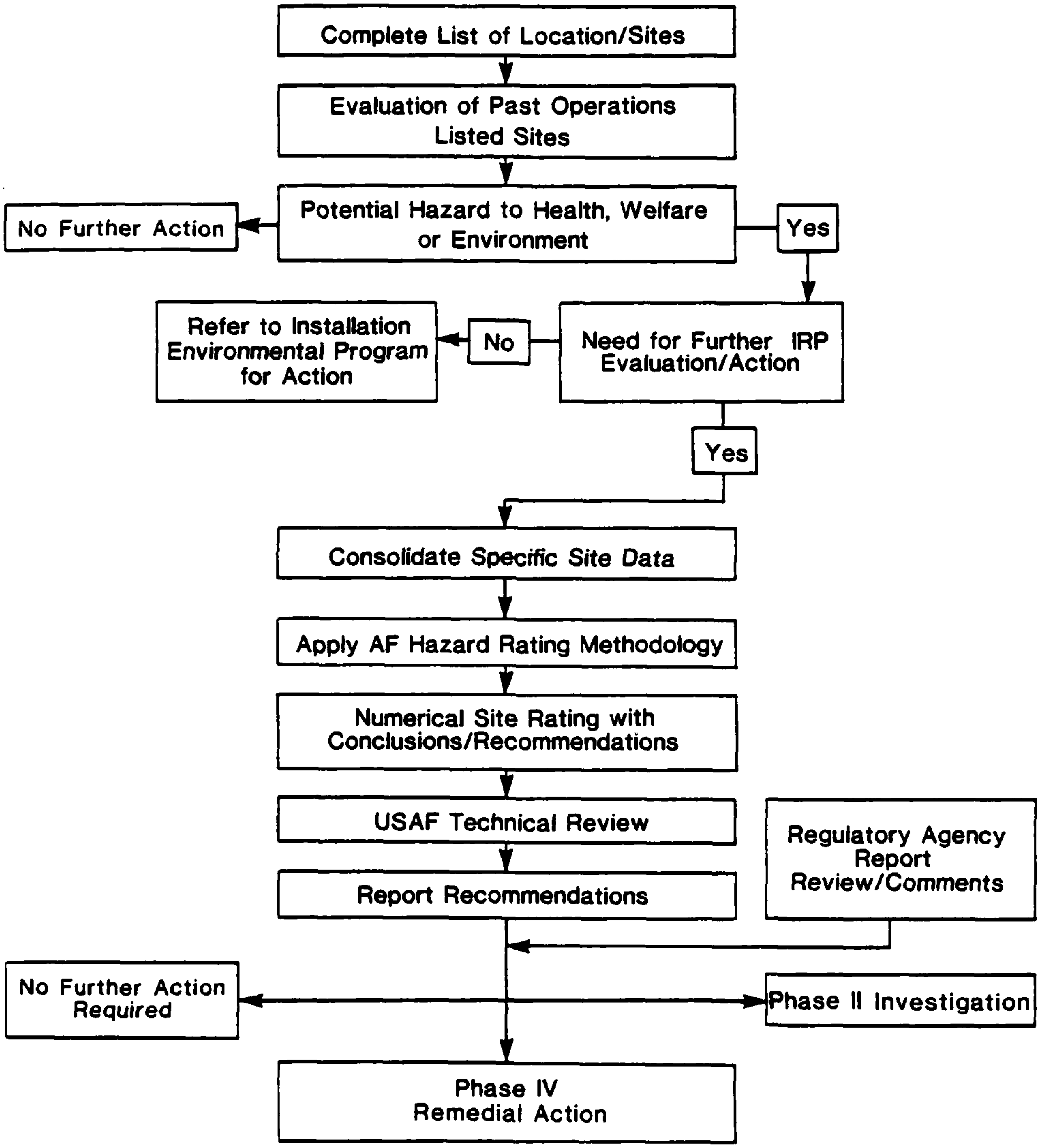
The next step in the activity review was to identify all sources of hazardous waste generation and to determine the past management practices regarding the use, storage, treatment, and disposal of hazardous materials from the various sources on the base. Included in this part of the activities review was the identification of all known past disposal sites and other possible sources of contamination such as spill areas.

A ground tour and an overflight of the identified sites were made by the Engineering-Science Project Team to gather site-specific information including: (1) general observations of existing site conditions; (2) visual evidence of environmental stress; (3) presence of nearby drainage ditches or surface waters; and (4) visual inspection of these water bodies for any obvious signs of contamination or leachate migration.

A decision was then made, based on all of the above information, whether a potential hazard to health, welfare or the environment exists at any of the identified sites using the flow chart shown in Figure 1.2. If no potential existed, the site received no further action. For those sites where a potential hazard was identified, a determination of the need for IRP evaluation/action was made by considering site-specific conditions. If no further IRP evaluation was determined necessary, but the site potentially could create an environmental problem in the future, then the potential problem was referred to the installation environmental program for appropriate action. If a site warranted further investigation, it was evaluated and rated using the Hazard Assessment Rating Methodology (HARM). The HARM score is a resource management tool which indicates the relative potential for adverse effects on health or the environment at each site evaluated.

PHASE I INSTALLATION RESTORATION PROGRAM

RECORDS SEARCH FLOW CHART



Source: AFESC

SECTION 2

INSTALLATION DESCRIPTION

F. E. Warren AFB is located in southeastern Wyoming on the west side of Cheyenne. The base is located 10 miles North of the Colorado border, and 40 miles West of the Nebraska state line (see Figure 2.1). The base is located in the central area of the Cheyenne Metropolitan Statistical Area and is bordered by agricultural land to the north, south and west, undeveloped residential land to the northeast and southwest and the City of Cheyenne on the east with some industrial development to the southeast (see Figure 2.2). The main base site comprises approximately 5,866 acres (see Figure 2.3 and Figure 2.4). Remote installation facilities consist of the following:

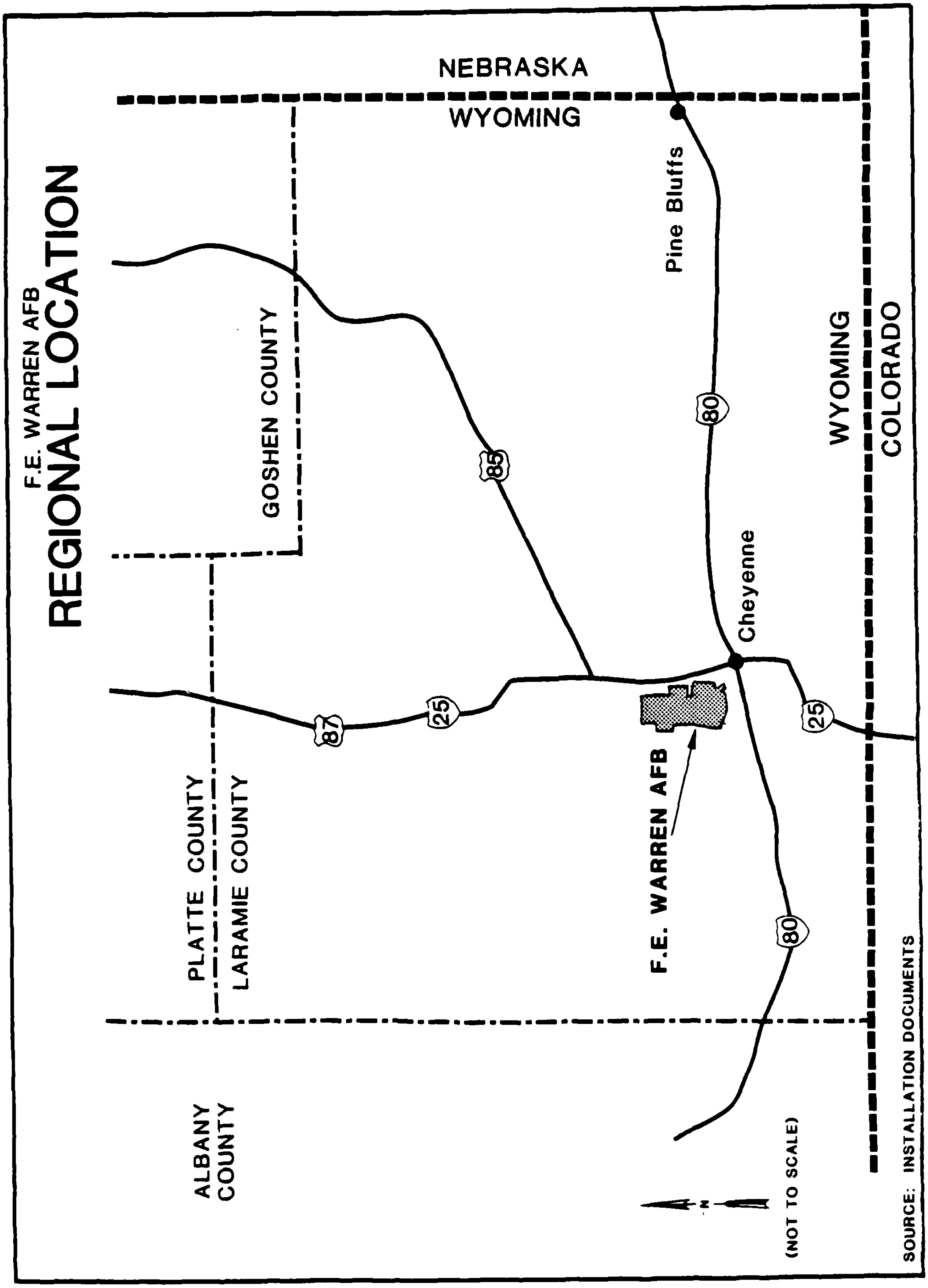
o Microwave Relay Station	1/4 Acre
o 90th Strategic Missile Wing (SMW) Sites	26,953 Acres

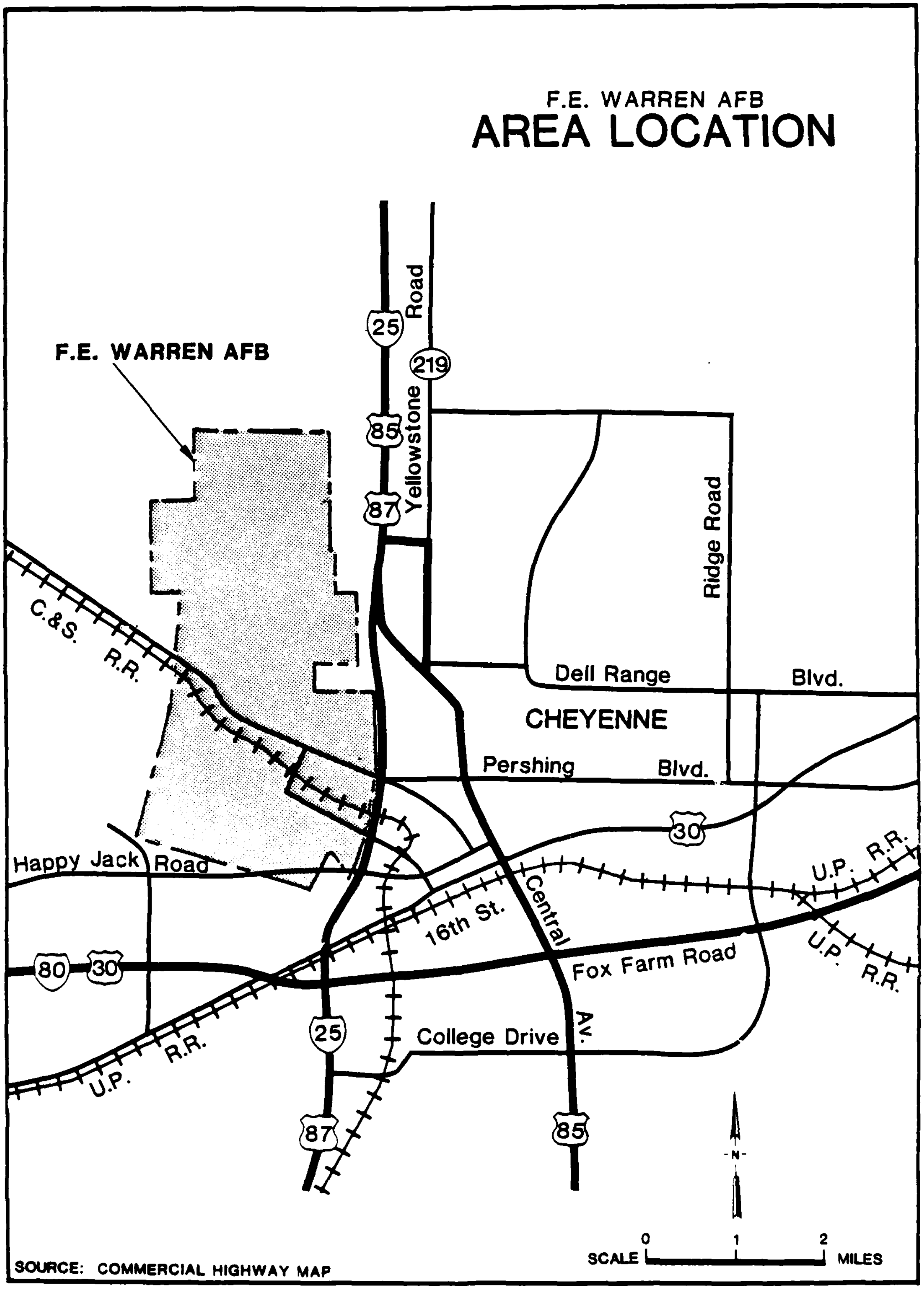
The 90th SMW consists of 20 Minuteman III Intercontinental Ballistic Missile (ICBM) Launch Control Facilities (LCFs) and 200 Minuteman III ICBM Launch Facilities (LFs) located in Wyoming, Nebraska, and Colorado. All of the LCFs and LFs are remote from the base. The 20 missile flights are located over a 12,000 square mile area. The missile LFs and LCFs are arranged in 20 flights (A-T) with an alphanumeric code as follows: A-01 indicates the LCF for flight A, A-02 through A-11 are the associated LFs. The same numerical designations hold for flights B through T. A diagram showing the approximate locations of the flights in relation to the base is presented in Figure 2.5.

BASE HISTORY

F. E. Warren AFB became a part of the Air Force System in 1947 and occupies an historic federal installation with its beginning in the last century. The base began as an army outpost in 1867 and was named Fort

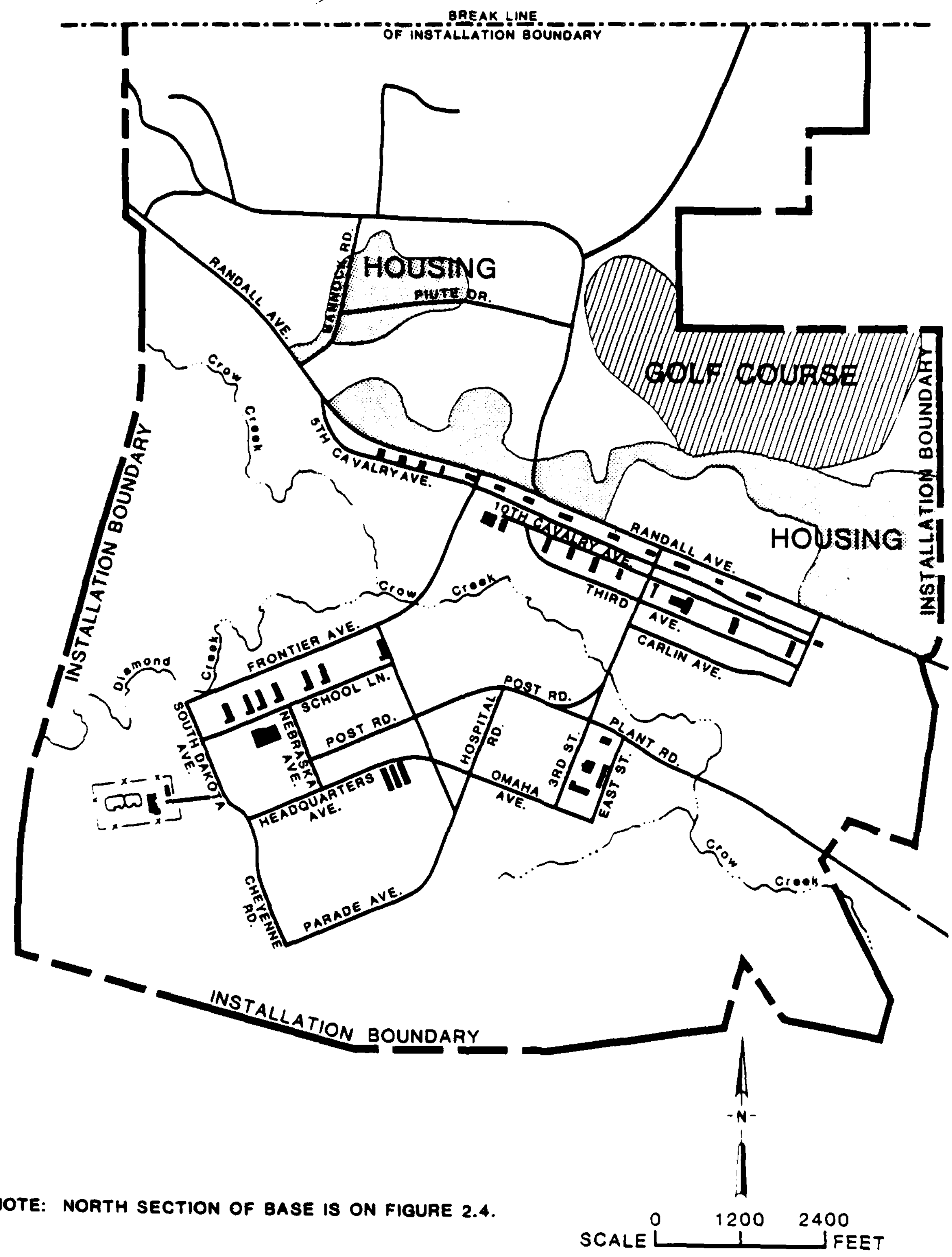
FIGURE 2.1


F.E. WARREN AFB
REGIONAL LOCATION
NEBRASKA
WYOMING
Pine Bluffs
GOSHEN COUNTY
85
80
WYOMING
COLORADO
Cheyenne
25
87
25
PLATTE COUNTY
LARAMIE COUNTY
F.E. WARREN AFB
80
ALBANY COUNTY
N
(NOT TO SCALE)
SOURCE: INSTALLATION DOCUMENTS



ES ENGINEERING-SCIENCE

F.E. WARREN AFB
INSTALLATION SITE PLAN - SOUTH

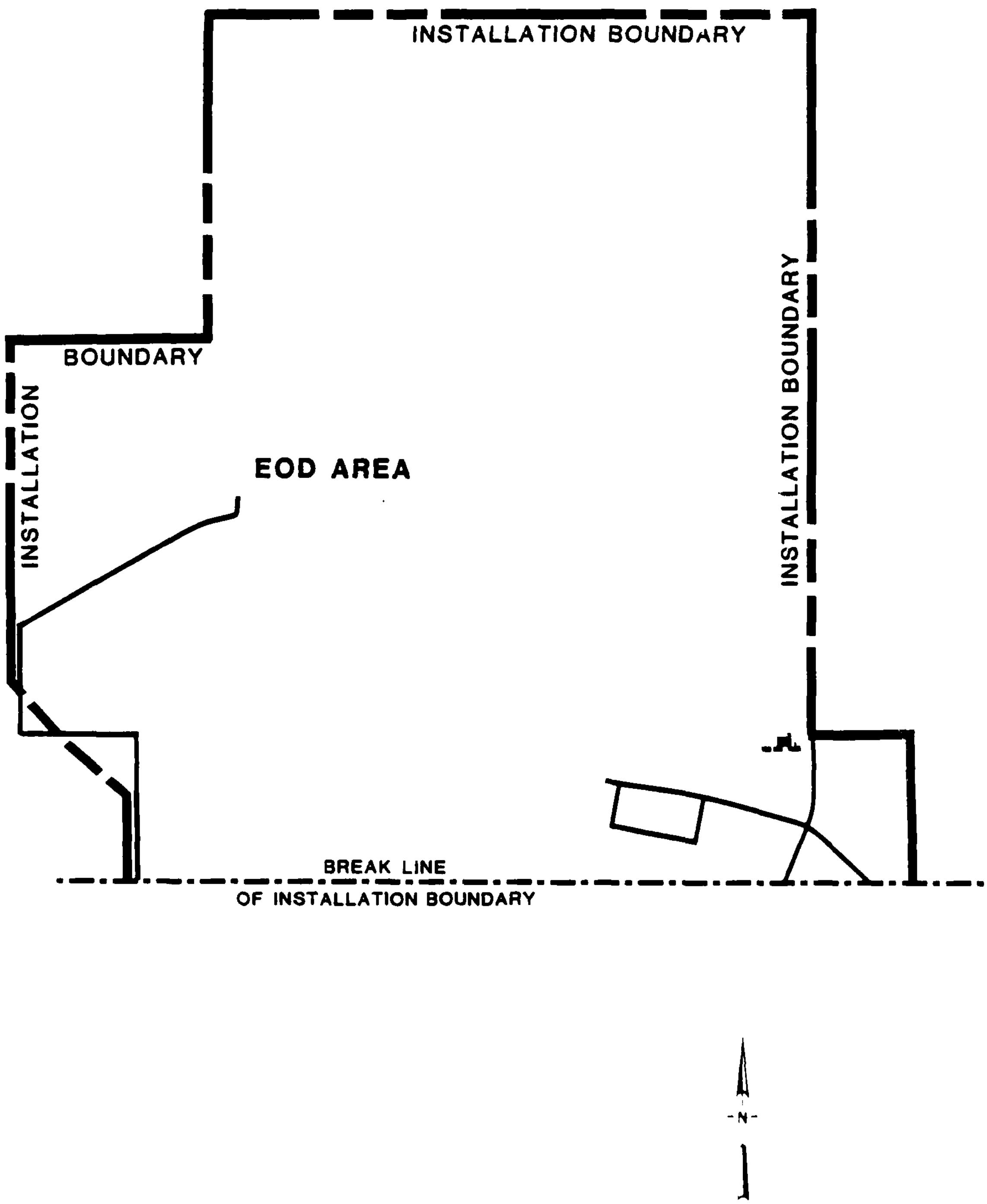


NOTE: NORTH SECTION OF BASE IS ON FIGURE 2.4.

SOURCE: INSTALLATION DOCUMENTS

F.E. WARREN AFB

INSTALLATION SITE PLAN – NORTH

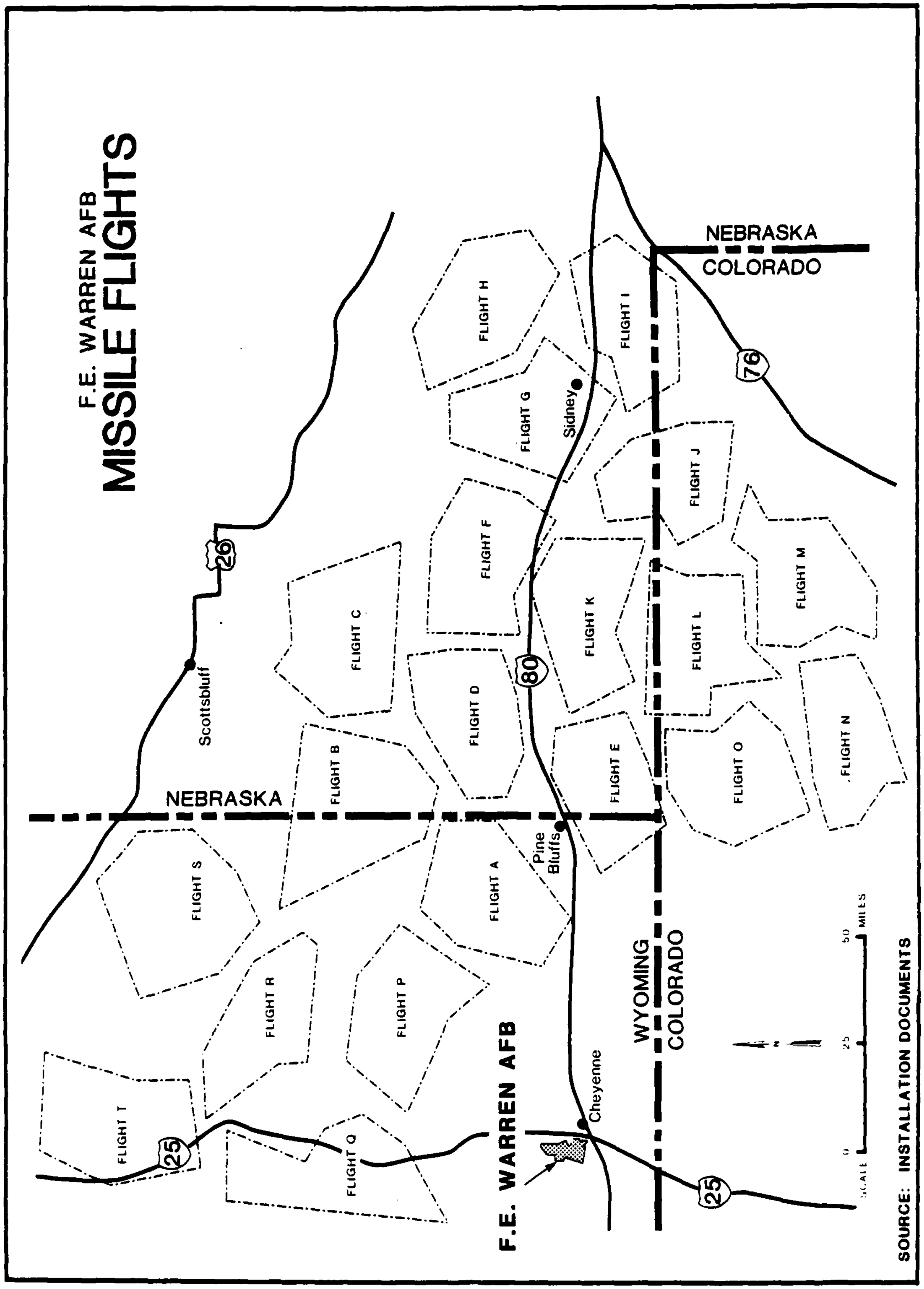


NOTE: SOUTH SECTION OF BASE IS ON FIGURE 2.3.

SCALE 0 1200 2400 FEET

SOURCE: INSTALLATION DOCUMENTS

ES ENGINEERING-SCIENCE



SOURCE: INSTALLATION DOCUMENTS

D. A. Russell. The post continued as a calvalry post through World War II as well as housing artillery units during World War I and II. The name was changed to Fort Francis E. Warren in 1930. The Fort was transferred to the Air Force in 1947 and was a training facility under TAC until 1958. SAC assumed command in 1958 and F. E. Warren AFB was selected as the first host base for the Atlas ICBM missile. The first Atlas D Missile arrived at F. E. Warren AFB in 1959 and by November, 1961 all 24 Atlas missiles were on combat ready status at F. E. Warren AFB. The Atlas missile was deployed in a similar configuration to the current Minuteman missiles with one LCF controlling three LFs for the 15 Atlas D missiles. The nine Atlas E missiles were each controlled from the nine responsive LCFs.

The Minuteman I missiles were deployed from F. E. Warren AFB starting in October, 1962 which coincided with the deactivation of the 24 Atlas sites. Full combat alert status was achieved in July of 1965 when all 200 Minuteman I missiles were in their silos and ready to respond to emergency war orders. The last Atlas ICBM was deactivated in January, 1965. The 90th Strategic Missile Wing became the host unit in 1963 and has retained that position until today. In 1975 a major upgrade program changing from the Minuteman I missile to the Minuteman III missile was completed at F. E. Warren AFB.

The base is currently undergoing another major program change in the deployment of 100 Peacekeeper missiles in the existing Minuteman silos. The remaining silos will continue to house the Minuteman III missile.

ORGANIZATION AND MISSION

The host unit at F. E. Warren AFB is the 90th Strategic Missile Wing (SMW). There are six major units in the 90th SMW. The Deputy Commander for Operations (DCO) controls the operations and management of the missile network; major subdivisions include the 319th, 320th, 321st, and the 400th Strategic Missile Squadron (SM) and the 2149th Communications Squadron (CS). The Deputy Commander for Maintenance (DCM) is responsible for missile maintenance; subdivisions include the 90th Organizational Missile Maintenance Squadron (OMMS) and the 90th Field Missile Maintenance Squadron (FMMS). The 90th Security Police Group

(SPG) is responsible for security, both on base and at the missile sites; organizations within the 90th SPG are the 88th, 89th and 90th Missile Security Squadron (MSS) and the 90th Security Police Squadron (SPS). The Deputy Commander for Resource Management (DCRM) controls the resources on the base, including supplies and transportation; major divisions are the 90th Transportation Squadron (TRNS) and the 90th Supply Squadron (SUPS). The 90th Combat Support Group (CSG) encompasses the service aspect and civil engineering operations on the base; the major units in the 90th CSG are the 90th Services Squadron (SVS) and the 90th Civil Engineering Squadron (CES). The sixth major unit, the USAF Hospital, F. E. Warren, provides health care to base personnel and their families in the area.

The tenant organizations at F. E. Warren AFB are listed below. Descriptions of the major tenant organization and their missions are presented in Appendix C.

- 4th Air Division
- 37th Aerospace Rescue and Recovery Squadron
- Detachment 10, 37th Aerospace Rescue and Recovery Squadron
- Geodetic Survey Squadron
- Detachment 1402, Office of Special Investigations
- The Defense Investigative Service
- Operating Location A, 9th Weather Squadron
- Peacekeeper Site Activation Task Force (SATAF)
- Operating Location FA, Detachment 15, 3904th Management Engineering Squadron
- Ogden Air Logistics Center

SECTION 3
ENVIRONMENTAL SETTING

The environmental setting of F.E. Warren AFB is described in this Section with an emphasis on the identification of natural conditions that may promote the migration of hazardous waste constituents. Environmental conditions pertinent to the study are summarized at the end of this Section.

CLIMATE

The climate of southeastern Wyoming can be characterized by the following generalizations: 1) Low relative humidity; 2) abundant sunshine; and 3) large daily and seasonal temperature variations. These conditions are somewhat typical for the northern part of the High Plains section of the Great Plains province.

In this portion of Wyoming, there are two major factors which produce its climatic features. One is the mid-latitude continental location which lies beyond the influence created by significant moisture sources. The other major factor is the high elevation (+6000 feet above mean sea level) with large topographic variations in the mountains to the west. Remoteness from moisture sources and high elevation result in low humidity and a semi-arid climate. Mean annual rainfall for Cheyenne is 13.4 inches. Table 3.1 illustrates the monthly precipitation averages.

Two climatic features important in determining the potential for movement of contaminants are net precipitation and rainfall intensity. Net precipitation is an indicator of the potential for leachate generation and is equal to the difference between precipitation and evaporation. Rainfall intensity is an indicator of the potential for excessive runoff and erosion. The one-year, 24-hour rainfall event is used to gauge the potential for runoff or erosion and is reported to be 1.25 inches (U.S. Weather Bureau, 1961). The mean annual precipitation at the

TABLE 3.1
CLIMATIC CONDITIONS AT F. E. WARREN AFB

Month	Temperature		Rainfall Precipitation		Snowfall Precipitation		Wind	
	Mean Max(°F)	Mean Min(°F)	Mean (in)	Max (in)	Mean (in)	Max (in)	Mean Speed (kts)	Prevailing Direction
JAN	38	16	.3	.7	5	13	12	WNW
FEB	41	15	.4	2.2	5	20	12	W
MAR	44	20	1.0	2.5	11	27	13	WNW
APR	54	29	1.3	2.3	8	22	12	WNW
MAY	64	39	2.4	5.4	3	18	11	WNW
JUNE	75	48	2.0	5.3	t	1	10	W
JULY	83	54	1.9	5.0	t	t	9	W
AUG	81	53	1.4	3.1	0	0	9	W
SEPT	72	44	1.1	4.5	1	7	9	W
OCT	61	34	.7	2.3	3	21	10	W
NOV	46	23	.6	2.5	7	31	11	WNW
DEC	40	16	.3	1.3	5	41	13	WNW
ANNUAL	--	--	13.4	--1	48	--	11	--

Period of Record: December 1949 - November 1979
Source: AWS Form 62, Climatic Brief for F.E. Warren AFB, WY., August 1980
Note: t = trace

base for the 30-year period of record is 13.4 inches (F.E. Warren AFB records) and the mean annual lake evaporation for the area is 57 inches (U.S. Weather Bureau, 1959). Net precipitation at F.E. Warren AFB is therefore minus 43 inches as determined from these climatic data. This very low net annual precipitation value suggests that there is little potential for water borne contaminants to infiltrate through surface soils to underlying units. The one-year, 24-hour rainfall is indicative of a low potential for runoff and soil erosion.

GEOGRAPHY AND TOPOGRAPHY

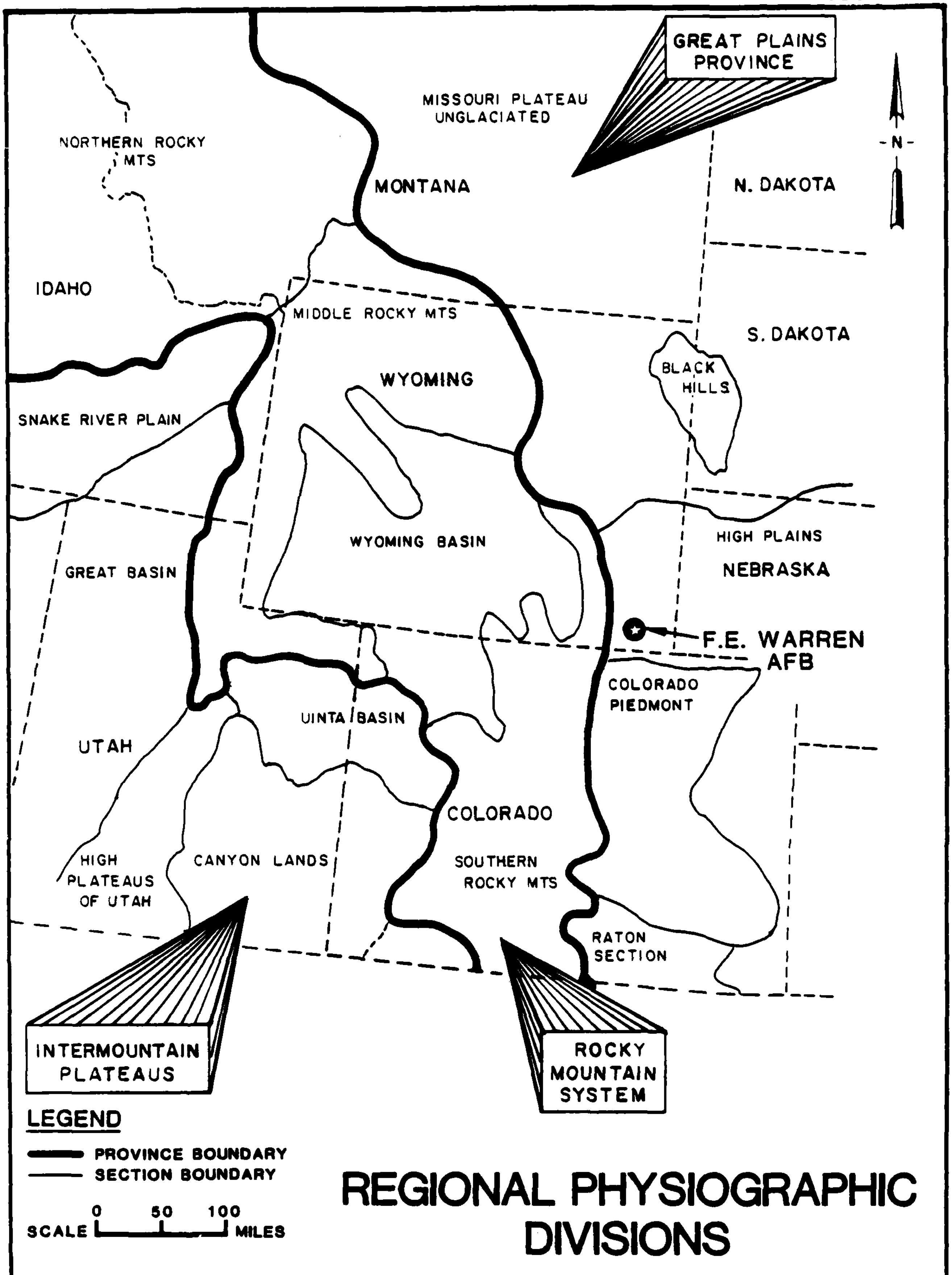
F. E. Warren AFB is situated within the western portion of the High Plains section of the Great Plains physiographic province (Figure 3.1). The Laramie Range which extends along the western edge of the county, is part of the Southern Rocky Mountains section. From the mountains eastward, the surface has been eroded to a relatively uniform plain that slopes gently eastward. Gradients range from 100 feet per mile west of the base to 20 feet per mile at the eastern edge of Laramie county. The surface has a gentle rolling topography of moderate relief and is marked by ephemeral and intermittent streams. The valleys become more deeply dissected as the mountains are approached.

The elevation of the city of Cheyenne is given as 6097 feet and highest elevations on the base are over 6300. The city and most of the base occupy the lower of two terraces which run northwest to southeast through the region. The lower terrace is 10 to 20 feet above the streams and a higher terrace lies 40 to 60 feet above the streams. These terraces are remnants of former valley bottoms which have been dissected by stream erosion since their formation (Cady, 1935). A NW-SE escarpment separates the terraces from the high plains and lies about 2 miles north of Randall Avenue.

Drainage

The region is drained by small eastward-flowing streams with headwaters in the mountains to the west. The northern one-third of the base drains through unnamed tributaries to Lodgepole Creek. The remainder of the base is drained by Crow Creek and its minor tributaries. Both streams flow into the South Platte River. Crow Creek which runs in a

FIGURE 3.1



REGIONAL PHYSIOGRAPHIC DIVISIONS

SOURCE: FENNEMAN (1931)

northwest to southeast direction through the base is the major drainageway to accept discharges associated with base operations (Figure 3.2).

As mentioned previously, streams have their headwaters in the mountains and are fed primarily by melting snowpack. As these streams flow from west to east, they often begin to lose water to the underlying permeable sediments of the Quaternary and Tertiary units. Crow Creek gains water in its channel (except through the city's well field) until it reaches the eastern edge of Cheyenne, where it begins to lose water under natural conditions to the underlying aquifer. Lowry and Crist (1967) have reported that Crow Creek at one time was a perennial stream from the mountains to a point about 12 miles east of Cheyenne. Where the stream flows through the city's well field, Crow Creek is generally dry because the groundwater level has been significantly lowered. Other streams in the area are intermittent, alternately gaining and losing water to the groundwater reservoir. This is important to base operations when it is considered that all of its drainage may enter the groundwater as a result of stream leakage.

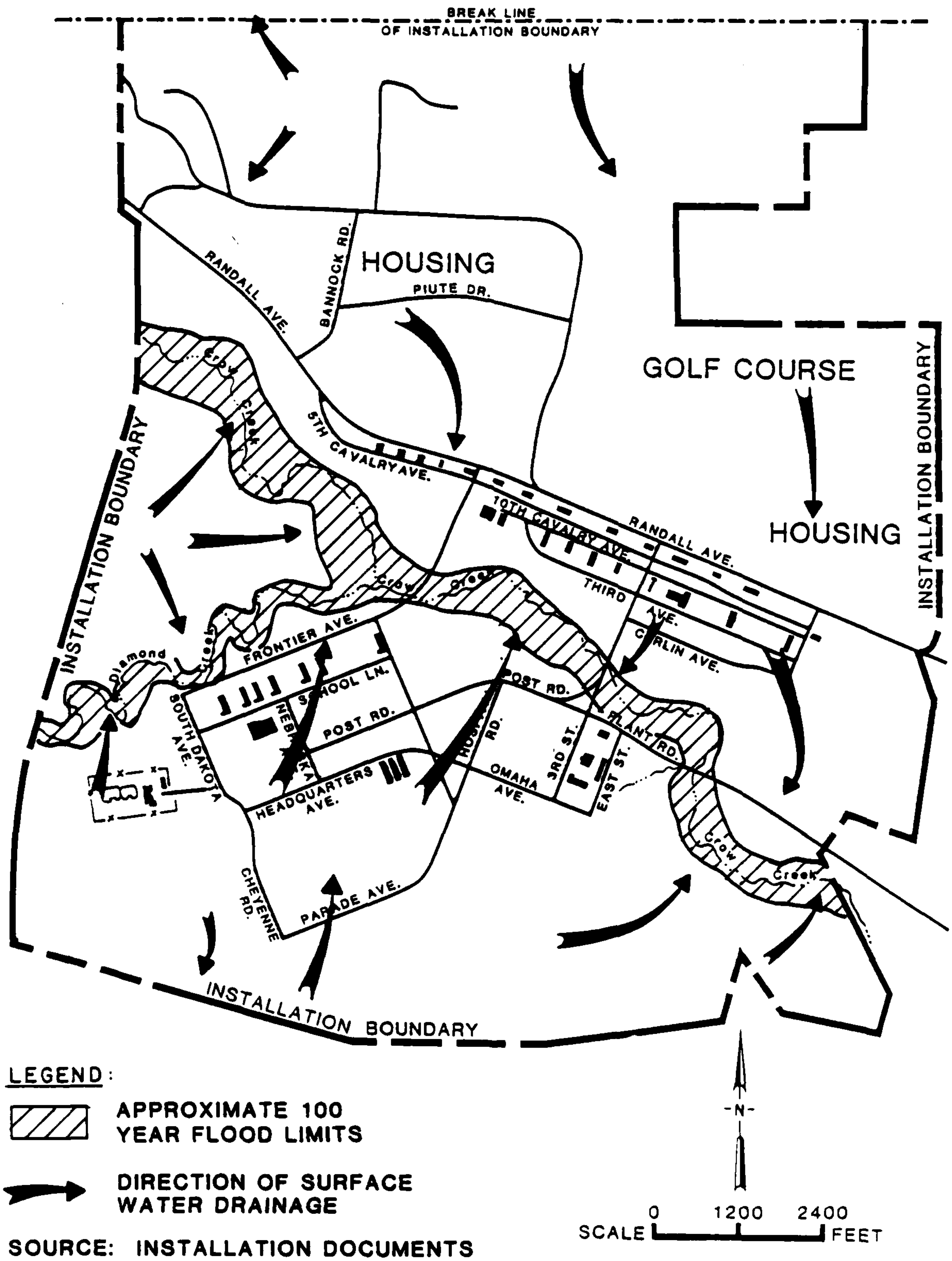
Surface Soils

A published report of the soils of western Laramie County which would include F.E. Warren AFB has not yet been issued. However, the distribution and character of the soils has been analyzed by the U.S. Department of Agriculture, Soil Conservation Service. Based on available data, Figure 3.3 illustrates the distribution of soils on Warren AFB. The character and physical characteristics of the soil types are described in Table 3.2.

In general, the soils are derived from ancient alluvial sediments of the Ogallala Formation and from alluvial floodplain sediments deposited by the current streams. Most of the base is covered by sandy and gravelly soils with low water holding capacity and moderate to rapid permeability. Some areas do exist where the soil is fine-textured, but these types occur mostly in the northern part of the base.

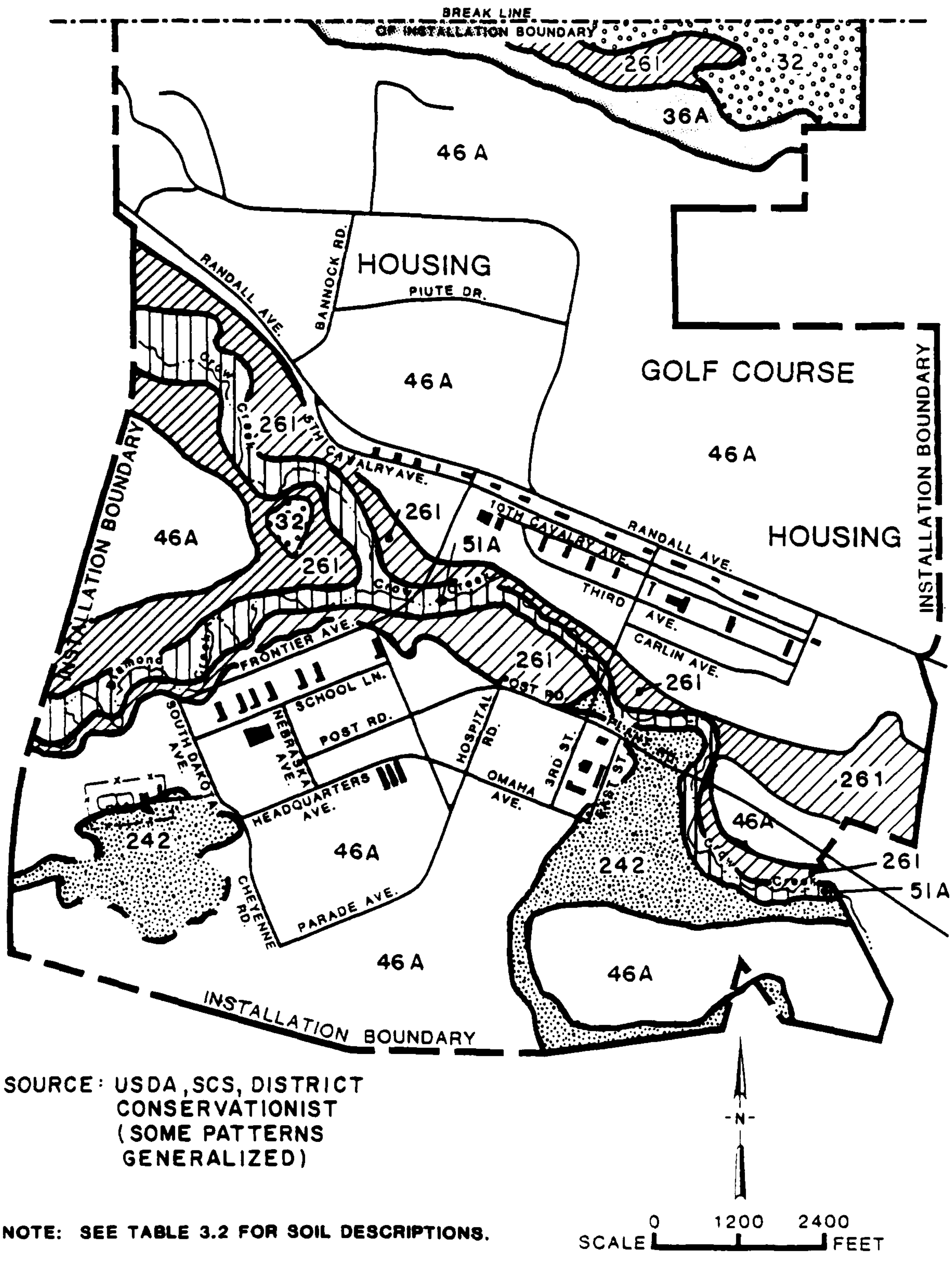
GEOLOGY

The geologic features of southeastern Wyoming have been described by many authors. Those cited by Lowry and Crist (1967) are the most



F.E. WARREN AFB

SURFACE DRAINAGE



SOURCE: USDA, SCS, DISTRICT CONSERVATIONIST (SOME PATTERNS GENERALIZED)

NOTE: SEE TABLE 3.2 FOR SOIL DESCRIPTIONS.

F.E. WARREN AFB

SOILS MAP

TABLE 3.2
F.E. WARREN AIR FORCE BASE SOILS

Map Symbol	Description	Thickness (in)	Permeability	Characteristics
46A	Altuon loam. Deep well-drained loam underlain by sand/gravel at 20-36 inches	+60	.2 - .6 in/hr.	0 to 6% slopes Moderate to rapid permeability Runoff is medium and erosion is slight to medium
242 (Mitchell) 261 (Dix)	Mitchell-Dix variant. Two soils 50% deep well-drained mostly silt loam (Mitchell). 40% deep well drained underlain at 7 in by sand, gravel (Dix)	+60	6-20 in/hr.	3 to 30% slopes Permeability moderate to rapid Runoff slow to moderate Erosion severe (Mitchell) to slight (Dix)
36A	Albinas loam. Sandy clay loam	+60	Moderate	0 to 3% slopes on low terraces Runoff medium Erosion is slight
435	Ascalon Variant loam. Deep well-drained moderately fine textured loam	+60	Slow	0 to 6% slopes Runoff is medium Erosion is slight High shrink/swell
32	Mitchell Silt Loam Deep well-drained	+60	Moderate	0 to 3% slopes Forms on calcareous silty material
51A	Merden silty clay loam. Poorly drained deep soil on flood-plains	+60	Slow	0 to 3% slopes Runoff is slow Erosion is slight High flooding potential. Water table at 1 to 3 feet

SOURCE: USDA, SCS, District Conservationist

important in defining the basic stratigraphic, structural and hydrogeologic characteristics of the Laramie County area. Crist and Borchert (1972) and Crist (1980) focus on the hydrologic features of the important High Plains aquifer of this region. The following discussion, though comprehensive, represents only a summary of the available information.

Stratigraphy

Geologic units ranging in age from pre-Tertiary to Quaternary outcrop within the area immediately adjacent to the base (Table 3.3). The majority of the region is underlain by Tertiary units which are of sedimentary origin and generally consist of sand, gravel, clay, siltstone, sandstone and limestone. These rocks are overlain by Quaternary sediments which include alluvial deposits underlying terraces and floodplains. These sediments are generally unconsolidated and consist of lenticular beds of clay, silt, sand, gravel and boulders.

Distribution

Figure 3.4 displays the surface distribution of the different geologic units in the area of study. F.E. Warren AFB is underlain entirely by the Ogallala Formation. Along the floodplains of Crow Creek and Diamond Creek, this formation is overlain by the recent alluvium deposited by these streams. The lateral and vertical distribution of underlying geologic units are shown on Figure 3.5.

Beneath the base, the Ogallala can be described as a heterogeneous mixture of sand and gravel beds, silt, clay and thin limestone units. The beds are sometimes cemented by calcium carbonate. In general, lenses of sand and gravel are sporadic, but at least in the southwestern part of the base, the permeable sand and gravel occur from the surface to a depth of about 10 feet. Below this depth, the predominate sediments are fine-grained but sand and gravel still occurs. The Ogallala is about 300 feet thick in the northern part of the base and thins to the south to about 150 feet in valleys where it has been deeply eroded. The Ogallala is underlain by important rocks of the Arikaree and White River Formations also of Tertiary age.

Structure

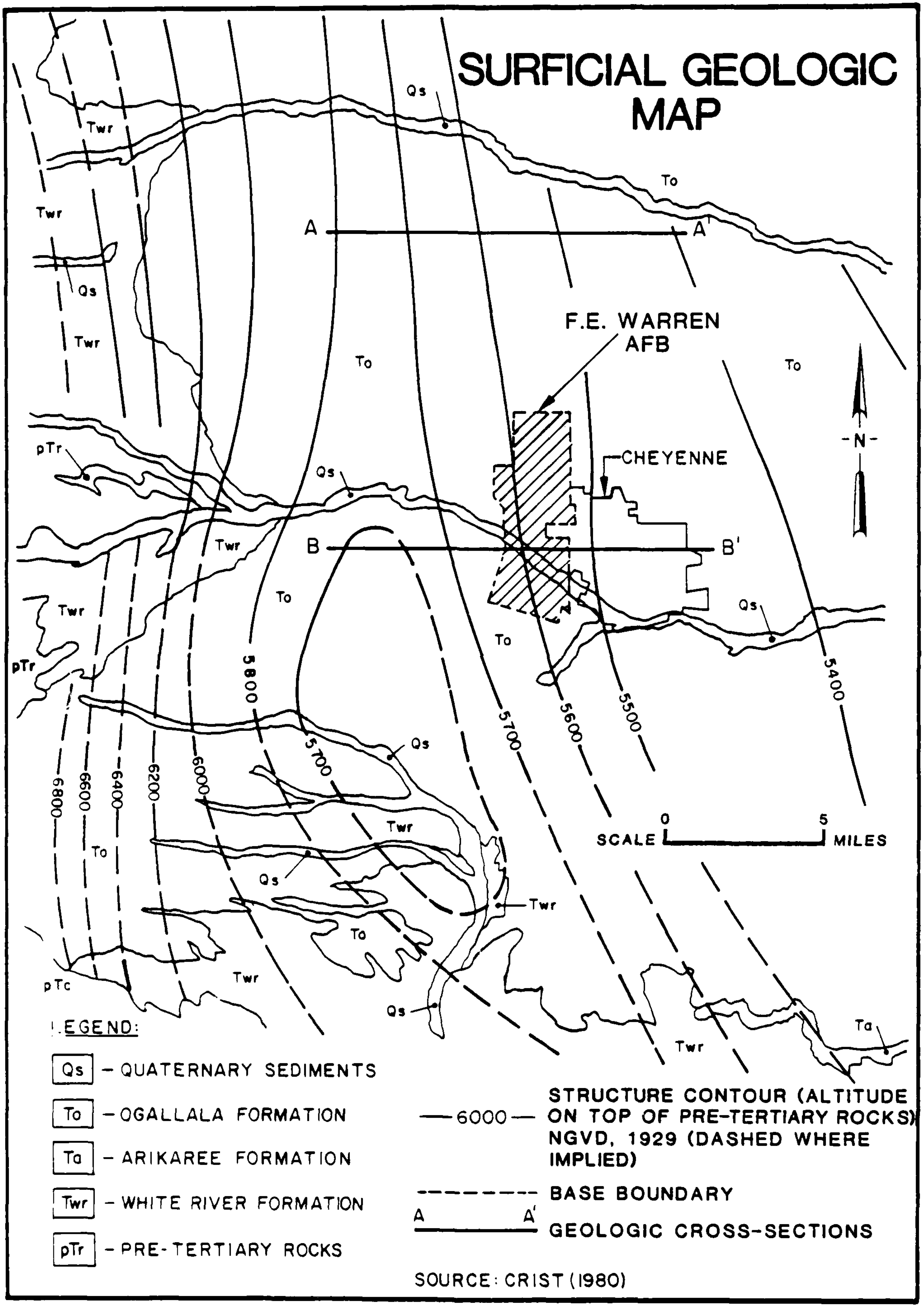
The structure contours drawn on the geologic map (Figure 3.4) illustrate the top of the pre-Tertiary rocks. These rocks were folded

TABLE 3.3
GEOLOGIC AND HYDROGEOLOGIC UNITS
F.E. WARREN AIR FORCE BASE

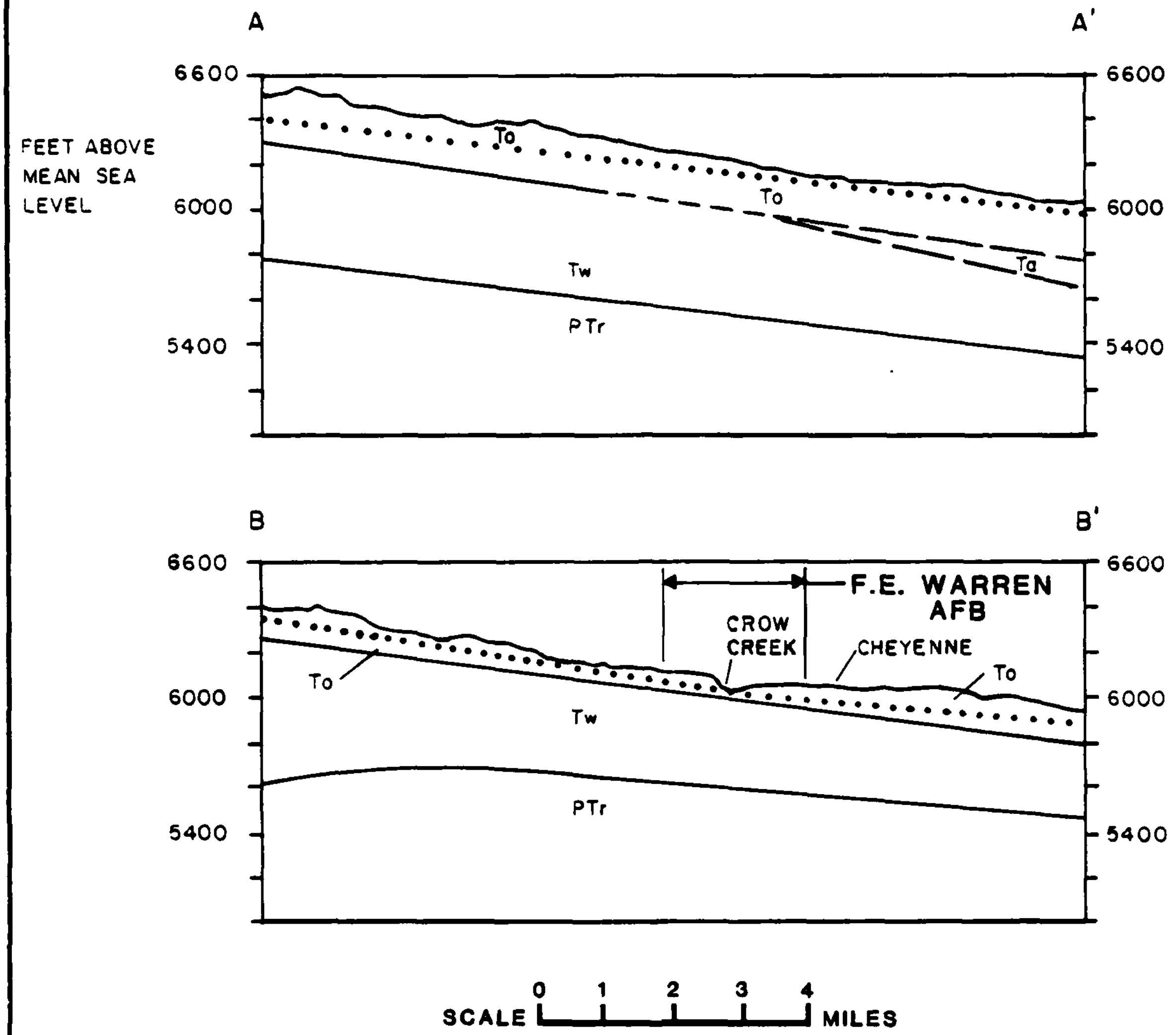
System	Series (Years)	Subdivision	Thickness (feet)	Character of Material	Water Supply	Hydrogeologic Unit
Quaternary	Recent (10,000 - present)	Flood-plain deposits	0-85	Lenticular beds of fine to very coarse sand, gravel, silt, and clay.	Yield small to moderate supplies to wells.	Surficial Aquifer
	Pleistocene (10^6 - 10^4)	Terrace deposits	0-200	Lenticular beds of coarse sand, gravel, silt, fine sand, and clay.	Yield large supplies to some wells.	
Tertiary	Pliocene (10^7 - 10^6)	Ogallala Formation	0-330	Heterogeneous deposits of gravel, sand and silt. May be either unconsolidated or well cemented.	Yields small to large supplies to wells.	High Plains Aquifer
	Miocene ($25X10^6$ - 10^7)	Arikaree Formation	0-450	Loose to well cemented fine-grained gray to white sandstone and silt. May be a coarse channel conglomerate at base in some areas.	Yields small to moderate supplies to most wells; large supplies could be obtained under optimum conditions.	
	Oligocene ($40X10^6$ - $25X10^6$)	White River Formation	0-500	Pinkish-brown siltstone. Contains beds of sandstone & conglomerate, principally near the mountains.	Yields large supplies from conglomerate & openings in siltstone; however, will probably yield only small supplies in most areas.	
Upper Cretaceous		Lance Formation	200-1500	Light-gray to yellow-brown sandstone; contains beds of soft shale and coal.	Yields small supplies. Deeper wells would probably obtain moderate yields; however, the water may be unfit for some uses.	Aquifer
		Fox Hills Sandstone	250±	Gray to yellow-brown silty sandstone interbedded with shale.	Not known to yield water to wells in the area.	Confining Unit?
		Pierre Shale	5700±	Predominantly dark-gray shale	Yields small supplies of water, generally poor in quality, from sandstone & fractured shale. The formation is not considered to be a good source of water.	Aquifer

SOURCE: Lowry and Crist, 1967

FIGURE 3.4



SURFICIAL GEOLOGIC MAP
F.E. WARREN AFB
CHEYENNE
A
A'
B
B'
Qs
To
Twr
pTr
pTc
Ta
5800
5700
5600
5500
5400
6800
6600
6400
6200
6000
-N-
SCALE 0 5 MILES
LEGEND:
Qs - QUATERNARY SEDIMENTS
To - OGALLALA FORMATION
Ta - ARIKAREE FORMATION
Twr - WHITE RIVER FORMATION
pTr - PRE-TERTIARY ROCKS
6000 STRUCTURE CONTOUR (ALTITUDE ON TOP OF PRE-TERTIARY ROCKS) NGVD, 1929 (DASHED WHERE IMPLIED)
BASE BOUNDARY
A A' GEOLOGIC CROSS-SECTIONS
SOURCE: CRIST (1980)



To - OGALLALA FORMATION
Ta - ARIKAREE FORMATION
Tw - WHITE RIVER FORMATION

} HIGH PLAINS AQUIFER (CONTACTS DASHED WHERE APPROXIMATE)

PTr - PRE-TERTIARY ROCKS

•••••••• POTENTIOMETRIC SURFACE OF HIGH PLAINS AQUIFER

GENERALIZED GEOLOGIC CROSS-SECTIONS

(CROSS-SECTION LOCATIONS ON FIGURE 3.4)

SOURCE: COOLEY AND CRIST (1980)

and eroded before the Tertiary beds were deposited. The region as a whole lies in a structural basin, known as the Denver Basin.

Granite and other Pre-Cambrian crystalline rocks form the core of the Rocky Mountains and rise to the surface about 20 miles west of F. E. Warren AFB. On the eastern flank of this core lies a thick series of sedimentary rocks which dip steeply to the east at 220 feet per mile. These rocks are Pennsylvanian to Cretaceous in age and outcrop in a narrow band about 13 miles west of the base. From this point east, the dip flattens out to about 40 feet per mile and these older rocks are (unconformably) overlain by the Tertiary units. The base of the entire Tertiary sequence of rocks is about 500 to 600 feet below the surface in the vicinity of F. E. Warren AFB.

HYDROLOGY

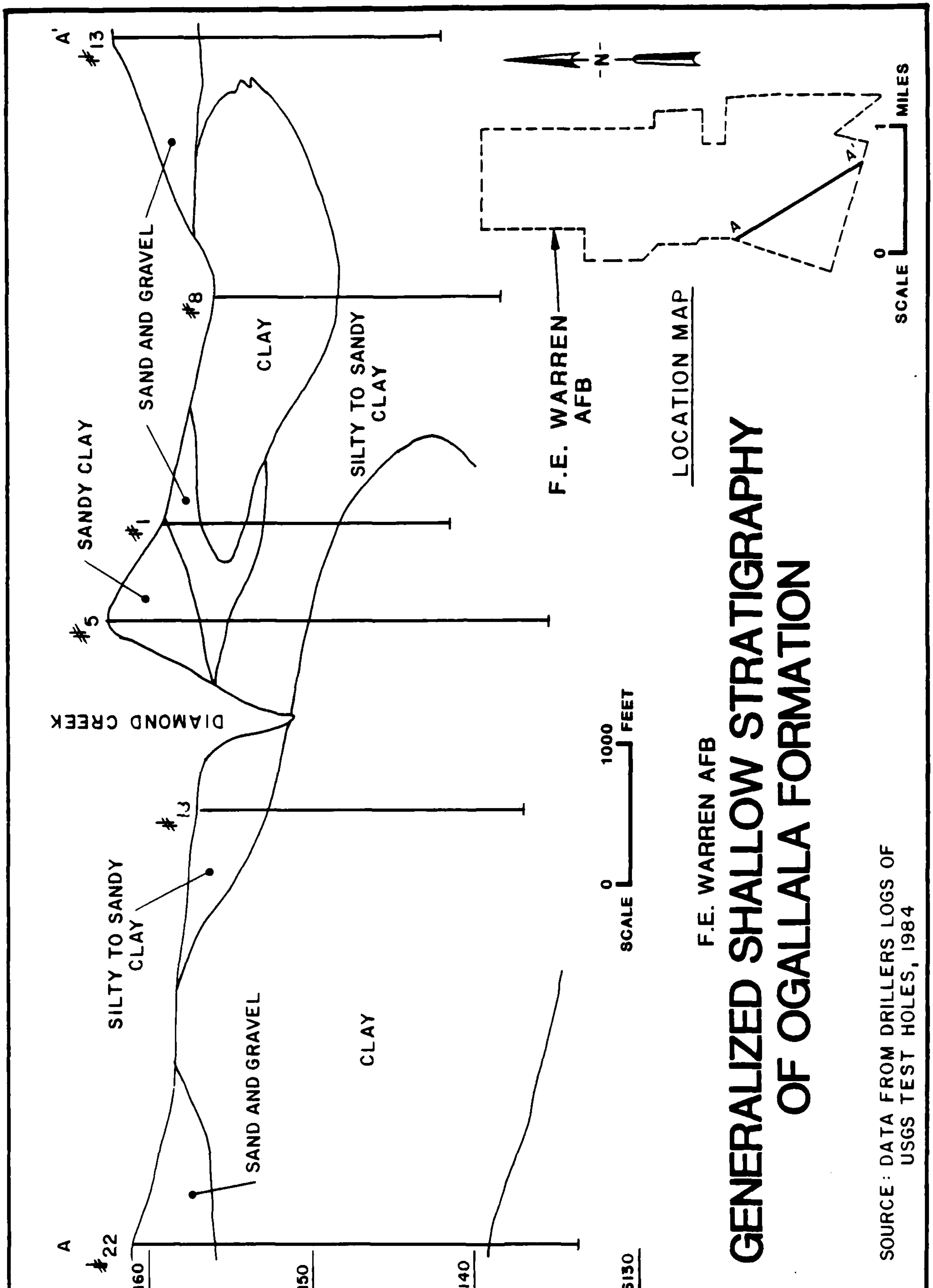
High Plains Aquifer

Alluvium, derived from the Rocky Mountains and transported by eastward flowing streams, was deposited across a vast plain stretching from Wyoming to Texas. This plain was formed during Tertiary time, but has since been eroded by natural processes. The remnant of the original plain exists as the High Plains and is an important area of groundwater use. The alluvial sediments comprise a series of geologic units, which along with Quaternary floodplain deposits, are known collectively as the High Plains aquifer.

The geologic units of the aquifer in ascending order are: the White River Formation (Oligocene age), the Arikaree Formation (early Miocene age), the Ogallala Formation (late Miocene age) and alluvial deposits (Quaternary age). These formations are described in Table 3.3. Figure 3.6 illustrates the character of the shallow aquifer beneath the base.

The individual units are considered as only one aquifer because they are generally in communication with each other during pumping conditions. The permeability of the aquifer is variable, but is generally capable of producing significant yields over much of the southeastern Wyoming area. The overall transmissivity of the Ogallala is estimated at 3000 gpd/ft with permeable units of 40,000 gpd/ft (Lowry and Crist, 1967). Theis (1940) reported well capacities up to 400 gpm for some

FIGURE 3.6



F.E. WARREN AFB
GENERALIZED SHALLOW STRATIGRAPHY OF OGALLALA FORMATION

SOURCE: DATA FROM DRILLERS LOGS OF USGS TEST HOLES, 1984

production wells used by the City of Cheyenne. Figure 3.7 illustrates the relative well density and groundwater use surrounding F. E. Warren AFB.

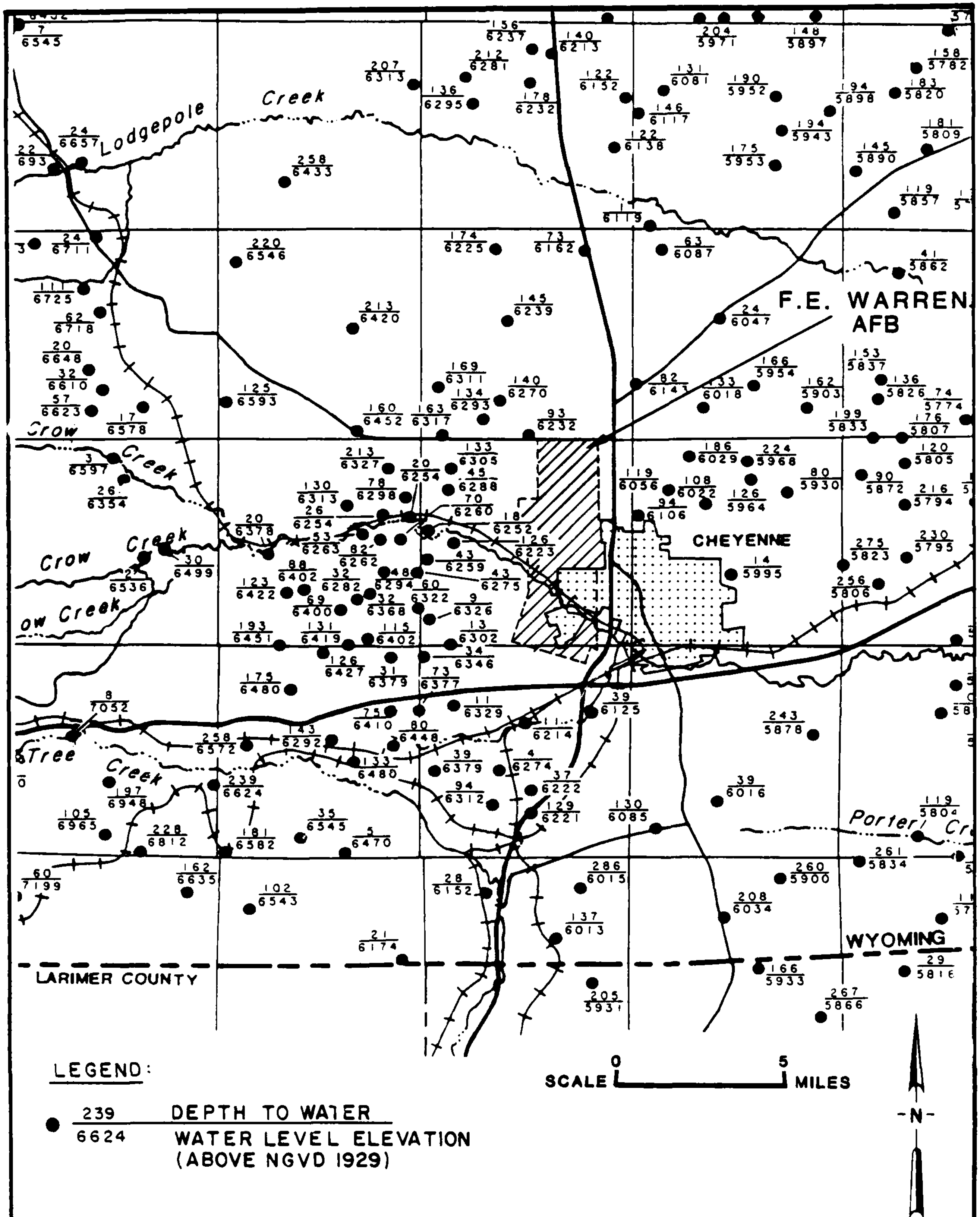
In general, the zones of highest permeability in the High Plains aquifer occur within sand and gravel beds present in all the units except the White River Formation. In this formation, the greatest permeability occurs where secondary permeability has developed as the result of fractures, piping (Lowry, 1966), and solution activity (Crist and Borchert, 1972). The secondary permeability appears to occur only in some areas where the Ogallala and Arikaree have been eroded away and younger alluvium has been directly deposited on the White River Formation (Crist, 1980). Where the White River outcrops east of Cheyenne, it produces over 300 gpm.

Groundwater flow through the High Plains aquifer is shown on Figure 3.8. Because of the importance of this aquifer in this part of Wyoming, water level measurements are periodically taken by the U.S. Geological Survey. In the area of F. E. Warren AFB, groundwater generally flows from west to east, but will locally discharge into Diamond and Crow Creeks. The figure also suggests that the depth to the water level beneath most of the base is generally less than 100 feet, but in the southwest portion of the base, it lies less than 10 feet below the surface. This is an important factor in assessing the potential for off-base migration of hazardous constituents from F. E. Warren AFB activities.

The High Plains aquifer is recharged not only along the outcrop area on the eastern flank of the Rockies, but also from direct precipitation and stream leakage in the Cheyenne area. Morgan (1946) estimated recharge from precipitation to be about 0.83 inches per year in the vicinity of Cheyenne, or about 5.5 percent of the average precipitation. As can be seen from the potentiometric surface map, Crow Creek generally accepts discharge from the aquifer within the base area, but east of Cheyenne, the aquifer is recharged by Crow Creek. Many smaller streams will also lose water to the aquifer, especially during the drier portions of the year.

Water Use and Water Quality

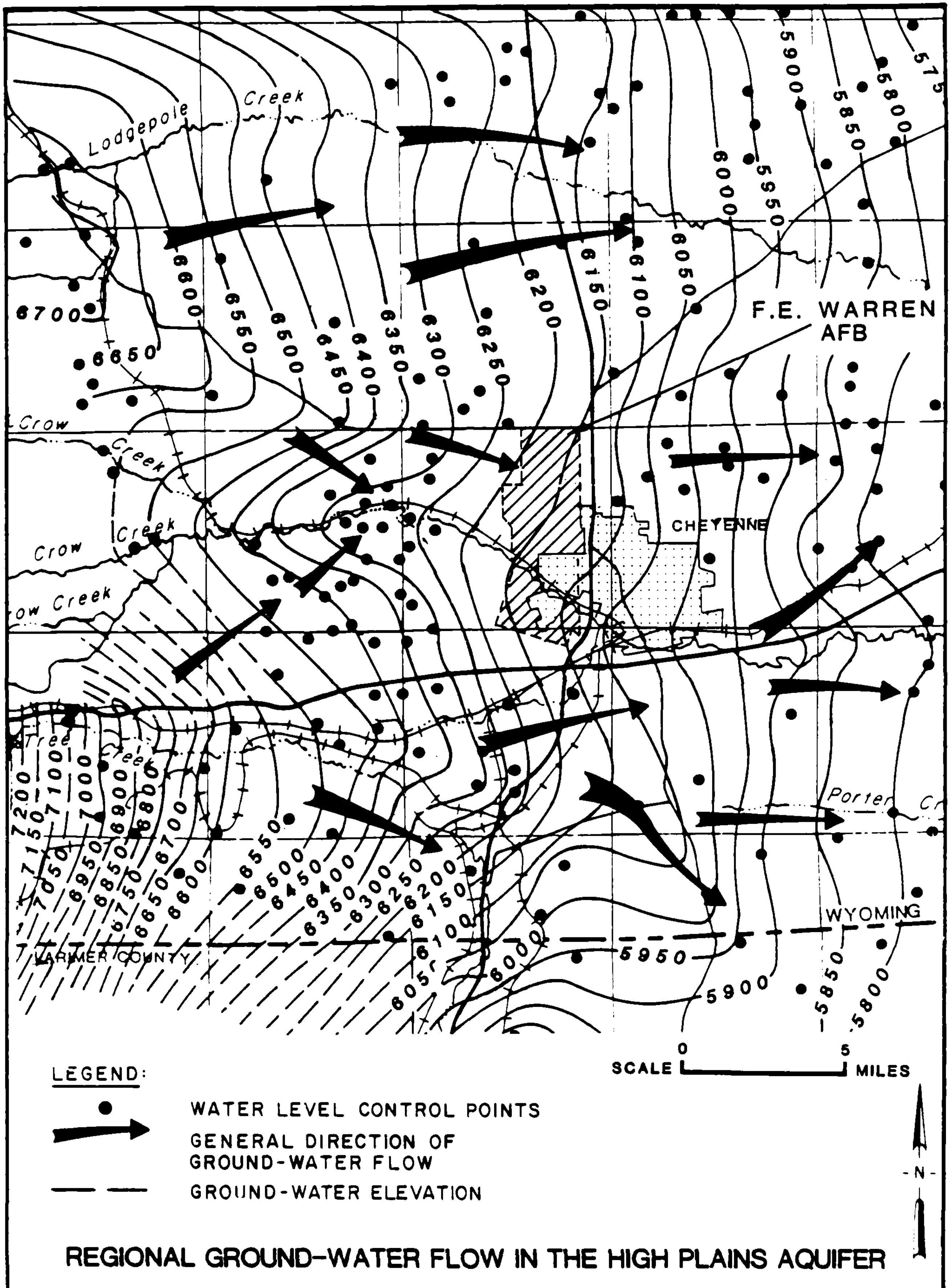
F. E. Warren AFB receives its water supply from the City of Cheyenne. The city's municipal supply is obtained from a well field 3



IRRIGATION AND MUNICIPAL WELL LOCATIONS

SOURCE : CRIST (1980)

FIGURE 3.8



REGIONAL GROUND-WATER FLOW IN THE HIGH PLAINS AQUIFER

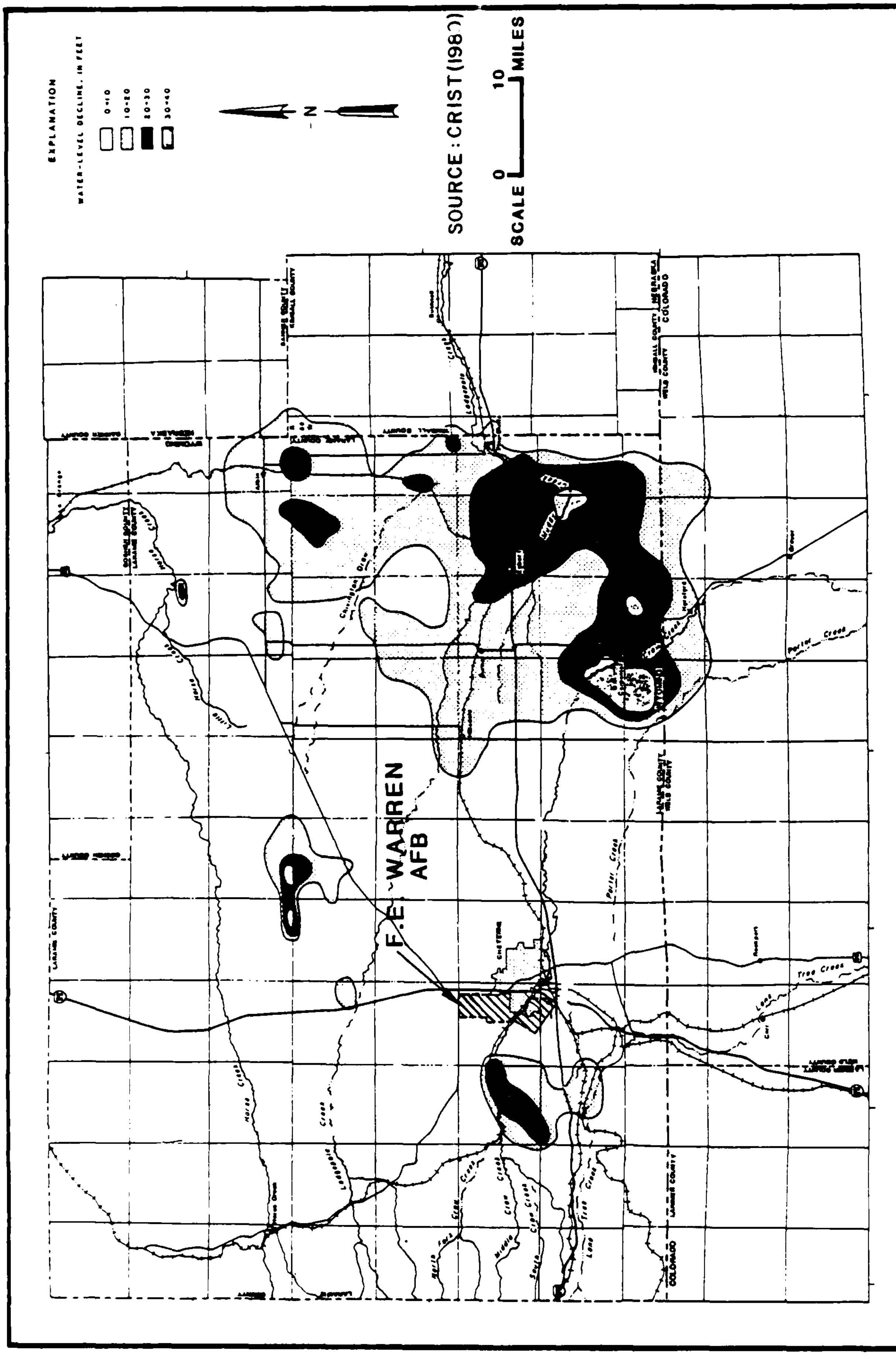
SOURCE: ADAPTED FROM CRIST (1980)

miles west of the base, from surface runoff in reservoirs on Crow Creek tributaries (west of the base) and from the Medicine Bow Mountains (100 miles west of the base). Groundwater is used extensively in the area, in particular for municipal, irrigation and domestic use. Many domestic wells are located outside the west boundry of the base along Roundup and Happy Jack Roads. The USGS (Crist, 1980) has used a computer simulation to predict the long-term decline of water levels in the aquifer in Laramie County (Figure 3.9).

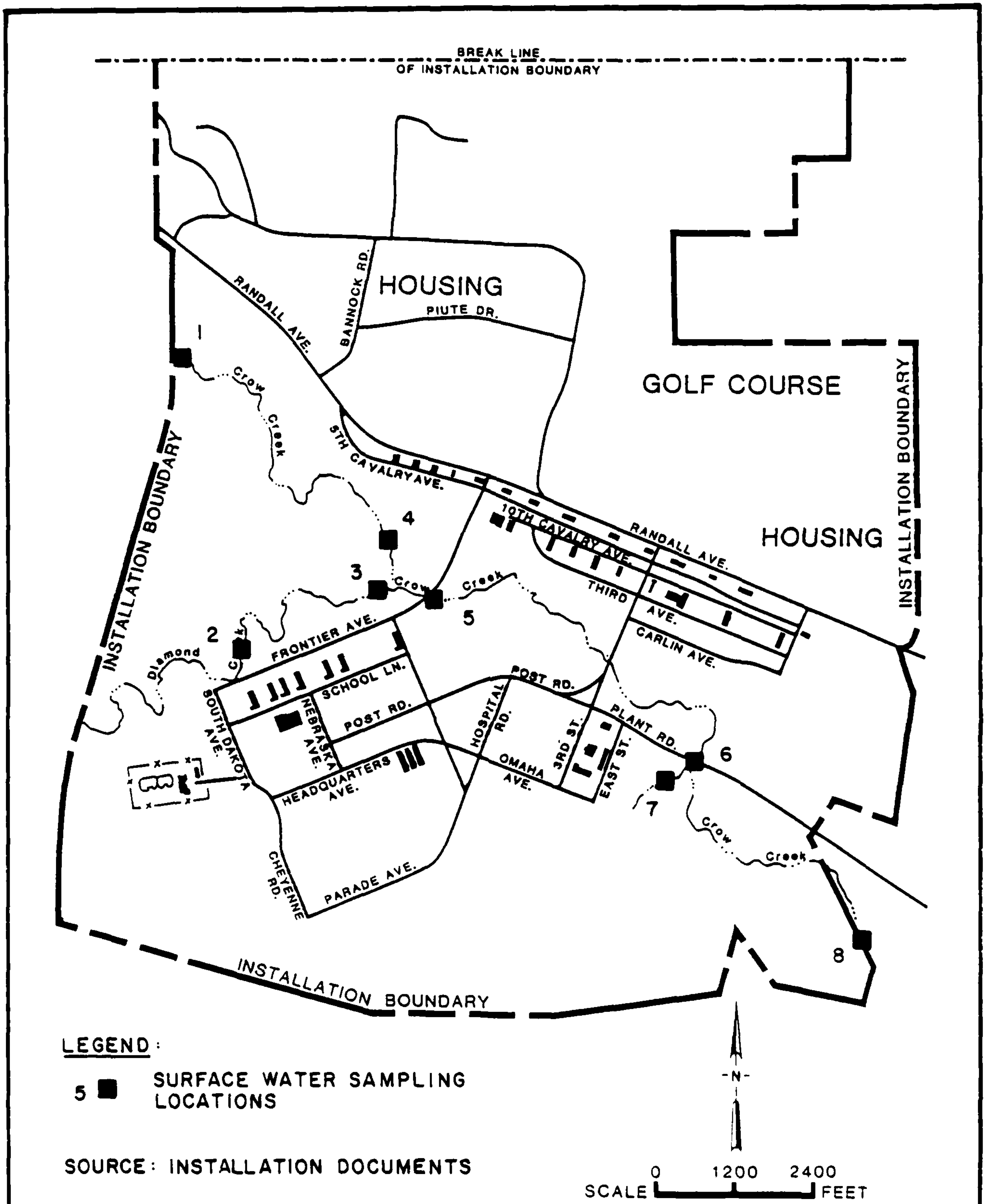
Groundwater quality from the High Plains aquifer in southeast Wyoming has been described in several reports: Lowry and Crist (1967), USGS (1971), Larson (1984). It is generally of good quality with very low dissolved-solids concentration. The median dissolved-solids concentrations of the Ogallala, Arikaree and White River Formation are 217 mg/l, 225 mg/l, and 257 mg/l, respectively (Larson, 1984). Levels within the Quaternary alluvium are generally higher ranging from 245 to 500 mg/l.

F. E. Warren AFB routinely samples the water quality of Diamond Creek and Crow Creek both upstream and downstream of base activities. The locations of these sampling sites are shown on Figure 3.10 and the data is presented in Appendix D, Tables D-1 and D-2. Based upon these data, the base appears to have no significant influence on surface water quality. However, sampling point No. 7 does show elevated levels of total dissolved solids (TDS), iron and manganese. This is probably the result of leachate from the landfill which is near this creek. Because the flow of this creek is intermittent, some of the drainage will be lost to groundwater.

An investigation was undertaken on the southwestern portion of the base following a leak of trichloroethlene (TCE) from a drum at the Building 1250 accumulation point. Soil borings were conducted and test wells installed to determine the impact on the soil and groundwater. Approximately 530 cubic yards of contaminated soil were removed from the area (March 1984). TCE contamination was discovered in the groundwater, which lies 7 to 17 feet below the surface at both the upgradient and downgradient wells. Additional wells were installed and monitoring is continuing to determine the source of the TCE. Additional information is provided in Section 4 under spills and leaks.



WATER LEVEL DECLINE OF HIGH PLAINS AQUIFER 1920-1987



F.E. WARREN AFB

SURFACE WATER SAMPLING LOCATIONS

Because of the importance of this aquifer in the surrounding area and because of the shallow water levels encountered, the potential impact of base activities on groundwater quality is high.

Threatened and Endangered Species

The moist meadow along Crow and Diamond Creeks and the unnamed drainage south of the Weapons Storage Area supports the larger of the two known remaining populations of the Colorado butterfly plant. The Colorado butterfly plant, a white flowering species of the evening primrose family, is rare in Wyoming and extinct in Colorado. It is on the Wyoming Endangered Species list. A protected habitat zone has been established at F. E. Warren AFB to minimize harm to the plant. No other threatened or endangered plant species are known to exist at F. E. Warren AFB.

No threatened or endangered animal species or potential critical habitat, have been identified at F. E. Warren AFB. Two species of concern in the southeastern part of the State are the swift fox and the meadow jumping mouse. Although suitable habitat may exist on bases, these species have not been observed.

ENVIRONMENTAL SUMMARY

Geographic, geologic and hydrologic data evaluated for this study indicate the following:

- An important, extensively used aquifer, the High Plains aquifer, underlies F. E. Warren AFB. The top of the aquifer or the water level surface lies within 10 feet of the surface within some areas of the base. Because the aquifer is heterogeneous, lenses of sand and gravel or permeable zones can exist at any depth up to 500 or 600 feet beneath the surface. The base is in an area which recharges to the High Plains aquifer by direct precipitation and also through stream leakage in some areas and at certain times of the year.
- The High Plains aquifer is used extensively for irrigation, municipal, and domestic supply wells which surround the base. The residences along Roundup and Happy Jack Road have private supply wells and the City of Cheyenne municipal supply well-field is located within 3 miles of the base.

- Crow Creek flows through the base in a northwest to southeast direction.
- Base surficial soils are predominantly sands and gravels that exhibit relatively high permeabilities.
- Annual net precipitation for the area is minus 43 inches. This condition reduces the potential volume of leachate generation resulting from precipitation at landfills located on F. E. Warren AFB.
- No wetlands exist at F. E. Warren AFB.
- The larger of the two known remaining populations of the Colorado butterfly plant, which is on the Wyoming Endangered Species list, exist in the moist meadow along Crow and Diamond Creeks and the unnamed drainage south of the Weapons Storage Area.

A potential does exist for the generation and migration of waste contaminants into and through the shallow Ogallala aquifer. Wastes disposed in areas adjacent to Crow Creek or Diamond Creek have been placed in the unsaturated portion of this aquifer. The aquifer is present at shallow depths and is recharged directly by precipitation and/or by communication with the streams. Waste migration would reasonably be expected to move through the shallow part of the aquifer and discharge into these creeks. At other times leakage from creeks into the aquifer can occur. The prevalence of surficial permeable sediments, their unpredictable lenticular occurrence, and the extensive groundwater use dictates conservative estimates of the base's potential impact on groundwater quality.

SECTION 4
FINDINGS

This section summarizes the hazardous wastes generated by installation activities, identifies hazardous waste accumulation and disposal sites located on the installation, and evaluates the potential environmental contamination from hazardous waste sites. Past waste generation and disposal methods were reviewed to assess contamination potential at F. E. Warren AFB.

INSTALLATION HAZARDOUS WASTE ACTIVITY REVIEW

A review was made of past and present installation activities that resulted in generation, accumulation and disposal of hazardous wastes. Information was obtained from files and records, interviews with past and present installation employees and site inspections.

The sources of hazardous waste at F. E. Warren AFB are grouped into the following categories:

- o Industrial Operations (Shops)
- o Waste Accumulation and Storage Areas
- o Pesticide Utilization
- o Fuels Management
- o Spills and Leaks
- o Fire Protection Training

The subsequent discussion addresses only those wastes generated at F. E. Warren AFB which are either hazardous or potentially hazardous. Potentially hazardous wastes are grouped with and referenced as "hazardous wastes" throughout this report. A hazardous waste, for this report, is defined by, but not limited to, the Comprehensive Environmental Response, Compensation and Liability Act of 1980 (CERCLA). Compounds such as polychlorinated biphenyls (PCB) which are listed in the Toxic

Substance Contral Act (TSCA) are also considered hazardous. For the purpose of this study, waste petroleum products such as contaminated fuels, waste oils and waste solvents are also included in the "hazardous waste" category.

No distinction is made in this report between "hazardous substances/materials" and "hazardous wastes". A potentially hazardous waste is one which is suspected of being hazardous although insufficient data are available to fully characterize the material.

Industrial Operations (Shops)

Information on industrial operations at F. E. Warren AFB was obtained from installation files and interviews. Bioenvironmental Engineering Services (BES) provided a listing of industrial shops as well as individual shop files indicating past hazardous materials utilized and hazardous material handling practices. This information was used in conjunction with personal interviews to determine which operations handle hazardous materials and which ones generate hazardous wastes. Summary information on all installation shops is provided as Appendix E, Master List of Shops.

The seven main units determined to be involved with the generation of potentially hazardous materials at F. E. Warren AFB are listed below:

- 90 Field Missile Maintenance Squadron
- 90 Civil Engineering Squdron
- 90 Transportation Squadron
- 90 Combat Support Group
- Detachment 10, 37 Aerospace Rescue and Recovery Squadron
- USAF AFB Hospital, F. E. Warren
- Army and Air Force Exchange Services

For the shops within these units identified as potential hazardous waste generators, file data were reviewed and personnel were interviewed further to determine types and quantities of materials generated and

present and past disposal methods. This information is summarized in Table 4.1.

Prior to the introduction of the missile mission at F. E. Warren AFB in the late 1950's, industrial operations were primarily base maintenance activities to support the training mission. During the Atlas missile era from 1958 to 1965, the missile shops were primarily located in Building 1250. Building 1250 now houses Detachment 10 of the 37th Aerospace Rescue and Recovery Squadron (ARRS). When the Minuteman missile was introduced in 1962, the new missile maintenance shops were located in their present locations in Buildings 332, 338, 340, and 341. Therefore, the Table 4.1 timelines for the 90th Field Missile Maintenance Squadron (FMMS) are begun in 1962.

Hazardous waste generation and disposal practices for the base prior to the late seventies are not well documented. Information obtained from interviews with personnel who were on-base prior to this time was used in developing the time lines in Table 4.1.

Reference in Table 4.1 to OBC refers to removal and off-base disposal by contract. Liquid wastes are removed by pumping directly from an oil/water separator, holding tank or holding drum, or by removing the entire drum. Disposal methods would include off-base resale, recycle, reclamation or landfilling.

The wastes generated in the shops at F. E. Warren AFB consist primarily of waste oils solvents (including paint thinners and strippers) and battery acids.

The waste oils and solvents are currently removed and disposed of off base by contract. This has been the general practice since approximately 1974, and has been handled through the Defense Property Disposal Office (DPDO) since 1981. Prior to 1974, much of the waste oils and solvents were burned in the Fire Protection Training Area (FPTA); the remainder was removed by an off-base contractor or placed in the base landfill. Small volumes of paint thinners used to clean brushes were also dumped on the ground at the various work sites.

Currently, waste battery acids are either removed to a local off-base facility or neutralized and discharged to a dry well west of Building 826, General Purpose Transportation. Prior to 1982, waste acids

TABLE 4.1

INDUSTRIAL OPERATIONS (Shops)

Waste Management

SHOF NAME	LOCATION (BLDG. NO.)	WASTE MATERIAL	WASTE QUANTITY	METHOD(S) OF TREATMENT, STORAGE & DISPOSAL 1950 1960 1970 1980
90TH FIELD MISSILE MAINTENANCE SQUADRON				
BATTERY SHOP	338	BATTERIES	100 BATTERIES/YR.	1962 LANDFILL 1982 DPDO
		BATTERY ACID	500 GALS./YR.	LANDFILL OBC
PRECISION MEAS. ELECTRONICS LAB	341	SILICONE OILS	6 GALS./YR.	1962 FPTA/LANDFILL 1974 OBC
		MERCURY	15 LBS./5 YRS.	DPDO
		HYDRAULIC FLUID	3 GALS./YR.	1962 FPTA/LANDFILL 1974 OBC
PERIODIC MAINTENANCE TEAM	336	ETHYLENE GLYCOL	400 GALS./YR.	SANITARY SEWER/LANDFILL OBC
		WASTE OIL	2,500 GALS./YR.	FPTA/LANDFILL OBC
PNEUDRAULICS	336	HYDRAULIC FLUID	600 GALS./YR.	OBC

KEY

——— CONFIRMED TIME FRAME DATA BY SHOP PERSONNEL

- - - - - - ESTIMATED TIME FRAME DATA BY SHOP PERSONNEL

OBC - REMOVAL AND OFF-BASE DISPOSAL BY CONTRACT

FPTA FIRE PROTECTION TRAINING AREA

DPDO DEFENSE PROPERTY DISPOSAL OFFICE

LANDFILL ON BASE LANDFILL

TABLE 4.1 (CONT'D)

INDUSTRIAL OPERATIONS (Shops)

Waste Management

SHOP NAME	LOCATION (BLDG. NO.)	WASTE MATERIAL	WASTE QUANTITY	METHOD(S) OF TREATMENT, STORAGE & DISPOSAL (1950 1960 1970 1980)
90TH FIELD MISSILE MAINTENANCE SQUADRON (continued)				
POWER REFRIGERATION ELECTRONIC LAB	336	SODIUM CHROMATE CONTAMINATED MATERIALS	10 DRUMS/YR.	1962 OBC
		ETHYLENE GLYCOL	350 GA S./YR.	SANITARY SEWER/LANDFILL 1974 OBC
90TH CIVIL ENGINEERING SQUADRON				
REFRIGERATION	367	COOLANTS	100 GALS./YR.	SANITARY SEWER
POWER PRODUCTION	316	STRIPPERS & SOLVENTS	100 GALS. YR.	EVAPORATION AND DISCHARGE TO GROUND
		WASTE OIL	500 GALS./YR.	FPTA,LANDFILL 1974 OBC
		SPENT ANTIFREEZE	70 GALS./YR.	FPTA,LANDFILL OBC
		BATTERY ACID	50 GALS./YR.	DISCHARGED TO GROUND 1975 LANDFILL 1982 OBC
ENTOMOLOGY	316	EQUIPMENT WASH WATER	GALS./YR.	DILUTED TO SEWER 1965 MAKE UP WATER
		EXPIRED PESTICIDES	10 GALS. YR.	LANDFILL 1984 DPDO
PROTECTIVE COATING	317	OLD PAINTS	30 GALS./YR.	LANDFILL 1984 OBC
		PAINT THINNER	20 GALS./YR.	EVAPORATION AND DISCHARGE TO GROUND

KEY

——— CONFIRMED TIME FRAME DATA BY SHOP PERSONNEL

- - - - - - ESTIMATED TIME FRAME DATA BY SHOP PERSONNEL

OBC REMOVAL AND OFF-BASE DISPOSAL BY CONTRACT

FPTA FIRE PROTECTION TRAINING AREA

DPDO DEFENSE PROPERTY DISPOSAL OFFICE

LANDFILL ON BASE LANDFILL

TABLE 4.1 (CONT'D)

INDUSTRIAL OPERATIONS (Shops)

Waste Management

SHOP NAME	LOCATION (BLDG. NO.)	WASTE MATERIAL	WASTE QUANTITY	METHOD(S) OF TREATMENT, STORAGE & DISPOSAL (1950, 1960, 1970, 1980)
90TH CIVIL ENGINEERING SQUADRON (Continued)				
HEATING PLANT	6501	WASTE OILS & LUBRICANTS	60 GALS./YR.	1983 OBC
HEATING SHOP	318	ASBESTOS INSULATION	5 CY/YR.	1947 LANDFILL
		SPENT HCl	200 GALS./YR.	NEUTRALIZED TO SANITARY SEWER; NOT GENERATED PRIOR TO 1984; 1984
EXTERIOR ELECTRIC	320	PCB TRANSFORMERS	600 GALS./YR.	OBC
90TH TRANSPORTATION SQUADRON				
GENERAL PURPOSE	826	WASTE OIL	5,000 GALS./YR.	1947 FPTA,LANDFILL; 1974 OBC
		SOLVENT (PD 680)	400 GALS./YR.	FPTA,LANDFILL; OBC
		BATTERY ACID	550 GALS./YR.	NEUTRALIZED TO DRY WELL
		BATTERIES	350 BATTERIES/YR.	LANDFILL,OBC; 1964 DPDO
		SPENT ANTIFREEZE	10 GALS./YR.	SANITARY SEWER
ALLIED TRADES	810	SOLVENTS (PD 680)	10 GALS./YR.	FPTA,LANDFILL; 1974 OBC
SPECIAL PURPOSE	810	WASTE OIL	3,600 GALS./YR.	FPTA,LANDFILL; OBC
		SOLVENT (PD 680)	400 GALS./YR.	FPTA,LANDFILL; OBC

KEY

——— CONFIRMED TIME FRAME DATA BY SHOP PERSONNEL

- - - - ESTIMATED TIME FRAME DATA BY SHOP PERSONNEL

NOTE: PCB MATERIALS SEGREGATED STARTING IN 1982.

OBC - REMOVAL AND OFF BASE DISPOSAL BY CONTRACT

OWS OIL/WATER SEPARATOR

FPTA FIRE PROTECTION TRAINING AREA

DPDO DEFENSE PROPERTY DISPOSAL OFFICE

LANDFILL ON BASE LANDFILL

TABLE 4.1 (CONT'D)

INDUSTRIAL OPERATIONS (Shops)

Waste Management

SHOP NAME	LOCATION (BLDG. NO.)	WASTE MATERIAL	WASTE QUANTITY	METHOD(S) OF TREATMENT, STORAGE & DISPOSAL 1950 1960 1970 1980
90TH COMBAT SUPPORT GROUP				
AUTO HOBBY SHOP	356	WASTE OIL	1,500 GALS./YR.	1947 FPTA/OBC 1974 OBC
		SOLVENTS	70 GALS./YR.	FPTA/OBC OBC
		ANTIFREEZE	200 GALS./YR.	FPTA/OBC OBC
PHOTO LABORATORY	242	SPENT FIXER AND DEVELOPER	100 GALS./YR.	SANITARY SEWER 1965 SILVER RECOVERY TO SANITARY SEWER
DETACHMENT 10, 37TH AEROSPACE RESCUE AND RECOVERY SQUADRON				
AEROSPACE GROUND EQUIPMENT (AGE)	1250	WASTE JP-4	10 GALS./YR.	FPTA LANDFILL OBC
		WASTE OIL	50 GALS./YR.	1968 FPTA/LANDFILL 1974 OBC
PNEUDRAULICS	1250	HYDRAULIC FLUID	50 GALS./YR.	1968 FPTA/LANDFILL 1974 OBC 1985
CORROSION CONTROL	1250	SOLVENTS	50 GALS./YR.	FPTA/LANDFILL OBC
JET ENGINE SHOP	1250	SOLVENT (PD-680)	5 GALS./YR.	FPTA/LANDFILL OBC
		WASTE OIL	10 GALS./YR.	FPTA/LANDFILL OBC
OPERATIONAL MAINTENANCE BRANCH	1250	WASTE OIL	200 GALS./YR.	FPTA/LANDFILL OBC
		SOLVENT (PD 680)	60 GALS./YR.	DISCHARGED TO GROUND 1978 SANITARY SEWER
		WASTE JP-4	300 GALS./YR.	FPTA/LANDFILL 1974 OBC

KEY

——— CONFIRMED TIME FRAME DATA BY SHOP PERSONNEL

- - - - - - ESTIMATED TIME FRAME DATA BY SHOP PERSONNEL

OBC REMOVAL AND OFF BASE DISPOSAL BY CONTRACT

LANDFILL ON-BASE LANDFILL

TABLE 4.1 (CONT'D)

INDUSTRIAL OPERATIONS (Shops)

Waste Management

SHOP NAME	LOCATION (BLDG. NO.)	WASTE MATERIAL	WASTE QUANTITY	METHOD(S) OF TREATMENT, STORAGE & DISPOSAL 1950 1960 1970 1980
USAF HOSPITAL, F.E. WARREN				
DENTAL LAB	160	LABORATORY CHEMICALS	10 GALS./YR.	1947 SANITARY SEWER
MEDICAL/DENTAL X RAY	160	SPENT DEVELOPER AND FIXER	1,500 GALS./YR.	SANITARY SEWER 1966 SILVER RECOVERY TO SANITARY SEWER
MEDICAL LAB	160	LABORATORY CHEMICAL	10 GALS./YR.	SANITARY SEWER
INCINERATOR	160	INCINERATOR ASH	12 CU.YD./YR.	LANDFILL
ARMY AND AIR FORCE EXCHANGE SERVICES				
SERVICE STATION	400	WASTE OIL	1,500 GALS./YR.	OBC/FPTA 1975 OBC

KEY

——— CONFIRMED TIME-FRAME DATA BY SHOP PERSONNEL

- - - - - - ESTIMATED TIME FRAME DATA BY SHOP PERSONNEL

OBC REMOVAL AND OFF BASE DISPOSAL BY CONTRACT

FPTA FIRE PROTECTION TRAINING AREA

LANDFILL ON BASE LANDFILL

were discharged to a dry well, landfilled, or dumped in the courtyard of Building 316, Power Production, and west of Building 338, Battery Shop. The dry well, landfills, and the major acid dumping locations are evaluated later in this section.

Waste Accumulation and Storage Areas

Wastes generated from the shops have generally been taken to storage areas designated as accumulation points. Accumulation points are centrally located either within a building or squadron or within a group of buildings. The waste accumulation point may consist of several drums, a storage tank, or a combination of drums and storage tanks. A listing of the drum and tank accumulation points is shown in Table 4.2.

Waste oils and antifreeze are taken from the accumulation tanks or drums and disposed of off base by contract. Other materials, for which special disposal arrangements must be made, such as sodium chromate, are held at the accumulation point for pickup by the off-base contractor. Past disposal practices for these wastes are summarized in Table 4.1.

Three of the waste accumulation points appear to have been in use for many years and numerous minor spills and leaks have reportedly occurred at these points. Therefore, they will be evaluated in regard to past disposal activities later in this section. The three accumulation points noted are:

1. Building 336, East Parking Lot, FMMS
2. Building 316, Courtyard, Power Production
3. Building 810, South Lot, Transportation

Some of the industrial shops at F. E. Warren AFB have discharge lines with oil/water separators for removal of oils, fuels, and cleaning solvents washed into the drains. A listing of the oil/water separators and their uses is presented in Appendix D, Table D.3. These tanks are pumped by an off-base contractor upon the request of the tank custodians. Contract arrangements are made through DPDO.

Pesticide Utilization

Pest management at F. E. Warren AFB is the responsibility of the Civil Engineering Squadron, Entomology Shop. Insecticide spraying and on-base herbicide applications are performed by Entomology. Pesticides

TABLE 4.2
WASTE ACCUMULATION AND STORAGE AREAS

Location	Storage Containers	Material
Building 4111, DPDO Storage	Drums and electrical equipment, concrete base, fenced	Waste oils
Building 336, East Parking Lot, FMMS	2 - 200 gal. storage tanks and drums, fenced area	Waste oils and antifreeze
Building 6501, East Heating Plant	Drums, concrete base with curb, fenced	Waste oils
Building 316, Courtyard	Drums, fenced area Power Production	Waste oils, anti-freeze, solvents, battery acid
Building 1250, East, ARRS	Drums, drip plate area	Waste oils, fuel, solvents
Building 810, South Lot, Transportation	300 gal. tank and drums	Waste oils, solvents
Building 400, Service Station	Underground tank	Waste oils, antifreeze
Building 356, Auto Hobby Shop	Underground tank	Waste oils, solvents
Building 336, Bulk Storage Room	Drums, indoors on concrete floor	Sodium Chromate
Building 602, PCB Bunker	Enclosed, secure area, concrete floor.	PCB contaminated material

and herbicides are stored in locked rooms in Building 316. A pesticide inventory list is provided in Appendix D, Table D.4.

The standard procedure for disposal of pesticide containers is to triple rinse and landfill on-base. The rinse water is usually returned to the tank for use as make-up of the next batch. Prior to 1984, no large pesticide disposal was likely to have occurred. Small amounts of expired pesticides may have gone to the base landfill.

Fuels Management

The F. E. Warren AFB fuels management system provides for storage and dispersing of JP-4, diesel fuel, natural gas, propane, coal, and motor vehicle fuel (MOGAS). A complete listing of storage facilities and their locations and capacities are identified in Appendix D, Table D.5.

All liquid fuels are delivered to the base by tank truck. Storage facilities exist on base for MOGAS, and diesel fuel. JP-4 for Detachment 10, 37 AARS is brought daily to the base from the Cheyenne Airport.

Coal is used in the base heating plant and is stored in open piles at the plant (Building 6501). All surface runoff from this storage area as well as boiler blowdown is routed to two settling ponds located east of the heating plant. Natural gas is delivered to the base by pipeline. A propane storage facility for back up fuel supply is located at Building 6403.

Spills and Leaks

Four significant spills/leaks of hazardous materials has been confirmed with base personnel. The locations of these sites are shown in Figure 4.1.

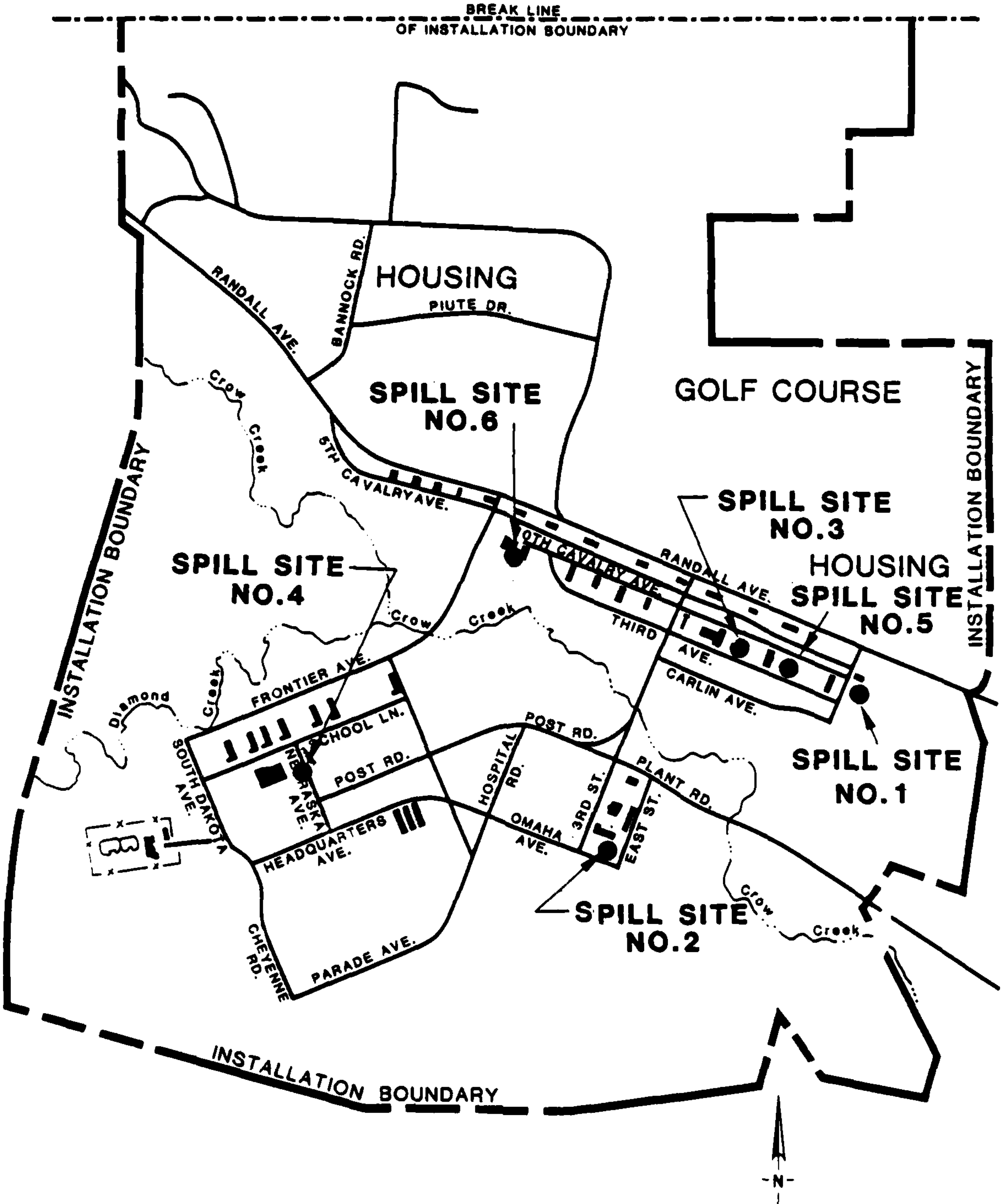
Spill Site No. 1

In 1973 the base service station, Building 400, experienced an estimated loss of 2,000-2,500 gallons of leaded MOGAS over a period of 6 months. Gasoline vapors were detected in the NCO Club and in a field east of the NCO Club. The storage tank was found to be the source of the leak and was replaced. Some fuel recovery was attempted and the vapors eventually dissipated.

Spill Site No. 2

Spill Site No. 2 consists of a September, 1983 oil spill and two waste accumulation and storage areas.

F.E. WARREN AFB
SPILL SITES



NOTE: THE NORTH SECTION OF THE BASE CONTAINED NO SPILL SITES.

SOURCE: INSTALLATION DOCUMENTS

In September, 1983 the contents of approximately thirty 55-gallon drums, which were stored at the south end of the lot south of Building 810, were dumped on the ground. These drums were thought to contain only water at the time they were dumped. However, the drums contained residues of hydraulic fluid and motor oil. Most of the liquid ran down East Street, adjacent to the lot, and was recovered.

The two waste accumulation and storage points which are also located in the lot south of Building 810 have experienced numerous spills of oil and hydraulic fluid. One accumulation point is located just south of Building 810 and consists of a 300-gallon waste oil tank and several 55-gallon drums. Although the tank is in a concrete dike, the ground around the tank is heavily stained with oil. The second accumulation point is located at the southern end of the lot and consists of several 55-gallon waste oil drums. The ground around these drums is also stained.

Spill Site No. 3

In April, May and June of 1980 used battery acid was disposed of by pouring on the ground west of Building 338. An estimated 150 gallons of battery acid (50 gallons/months) was disposed of in this manner.

Spill Site No. 4

In October 1982 pin hole leaks in a drum of Trichloroethylene (TCE) were discovered at Building 1250. An estimated 15-20 gallons of TCE was lost. Soil tests were made to determine the extent of soil contamination and 530 cubic yards of contaminated soil was removed. Three wells were installed in the area to monitor the groundwater. Elevated levels of TCE, chloroform and other organic contaminants were detected in the groundwater samples taken from these wells. The location of the wells and the groundwater quality data are presented in Appendix D, Figure D-1 and Table D-6, respectively. Three additional wells have been installed and the groundwater has been found to be contaminated with TCE, chloroform and other organic compounds. The source of contamination is currently unknown. A potential source is thought to be Building 1250 which was the site of the Atlas missile maintenance shops when the Atlas missile was based at F. E. Warren AFB.

Spill Site No. 5

The waste oil accumulation point east of Building 336 identified as Spill Site No. 5. There are two 200 gallon tanks located in a fenced area of the parking lot. One contains used oil and the other contains waste antifreeze. Also contained in the fenced area are several 55-gallon drums which contain waste and clean oil. The area has been in use since approximately 1962 and there is visual evidence of oil spills.

Spill Site No. 6

Spill Site No. 6 is the waste accumulation point located in the courtyard of Building 316 and the yard south of Building 316 which is used as a radiator cleaning area. The courtyard has been used as an accumulation point by Power Production since at least 1962 and currently drums of new and waste oil are stored here. Numerous oil spills have reportedly occurred in the courtyard. Until 1982 waste battery acid was also dumped on the ground in the courtyard. The courtyard area has recently been covered with fresh soil.

Fire Protection Training

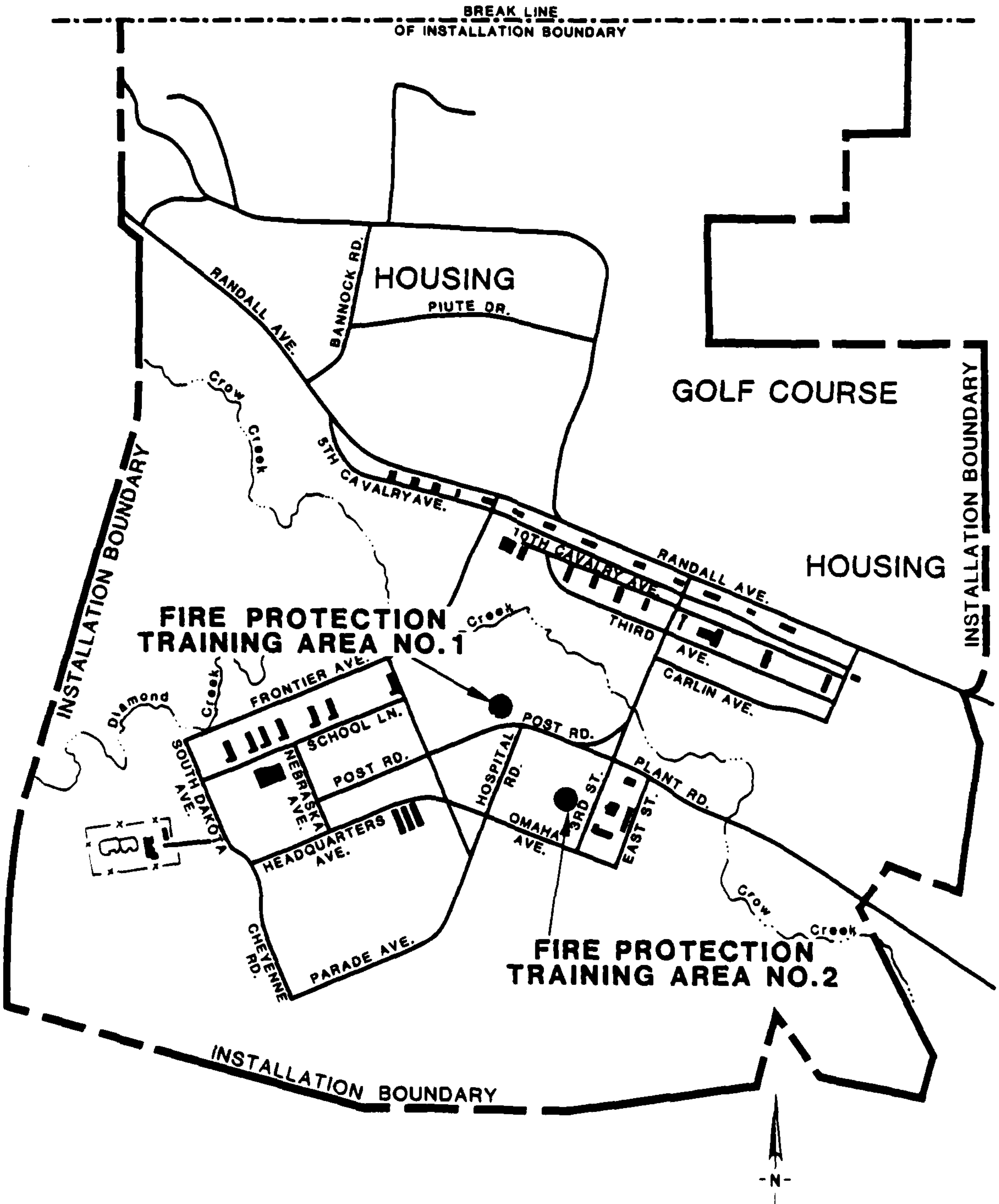
The fire department at F. E. Warren AFB has operated two fire protection training areas (FPTAs) since the base was made operational. Figure 4.2 gives the locations of the 2 FPTAs.

FPTA No. 1 was located near Crow Creek and was utilized from 1950 to 1965. There were no fuel storage facilities at the site. Waste oils, solvents, gasoline, JP-4 and other combustible liquids were used in the training exercises. Training exercises were conducted 3-4 times per month and an estimated 500 gallons of flammable liquids were consumed in each exercise. The area was not pre-wet prior to training. Water and protein foam were used as extinguishing agents. Runoff from the site entered Crow Creek.

FPTA No. 2 is located between Omaha Avenue and Missouri Avenue, and has been used since 1965. Waste oils, solvents, hydraulic fluid and other combustible liquids were used in training exercises until 1974. Since 1974 only JP-4 has been used in the training exercises. There are no fuel storage facilities at the site. Presently fire training exercises occur twice per month and three to four hundred gallons of JP-4 are consumed per exercise. AFFF and water have been

F.E. WARREN AFB

FIRE PROTECTION TRAINING AREA SITES



NOTE: THE NORTH SECTION OF THE BASE CONTAINED NO FPTA'S.

SOURCE: INSTALLATION DOCUMENTS

used since 1972 for extinguishing fires. Runoff from the area drains to Crow Creek.

INSTALLATION WASTE DISPOSAL METHODS

The facilities at F. E. Warren AFB, which have been used for the management and disposal of waste, can be categorized as follows:

- Landfills
- Hardfill Disposal Areas
- Sanitary Sewer System
- Explosive Ordnance Disposal Area
- Acid Dry Well

Landfills

On-base landfills at F. E. Warren AFB have been used for disposal of non-hazardous solid wastes and some industrial waste materials. Landfills have been operated in the past at six locations, as shown in Figure 4.3. A summary of the pertinent information associated with these landfills is presented in Table 4.3.

Landfill No. 1

Landfill No. 1 was operated from 1867 until 1900 and is located east of Fourth Avenue and north of Crow Creek. The landfill was probably in a natural depression, and was fill only. No hazardous waste is suspected of being deposited here. The site is closed, and has a soil and grass cover.

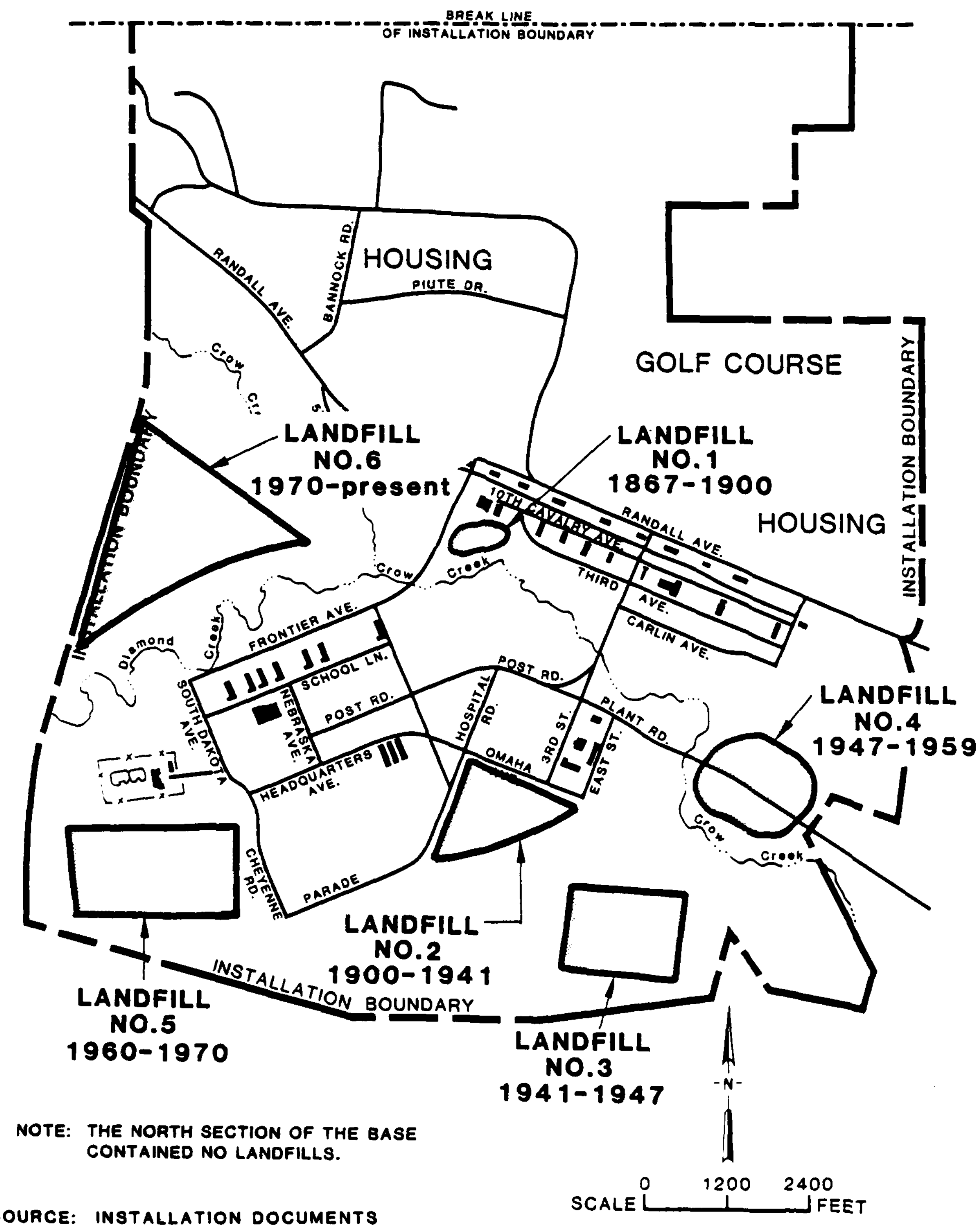
Landfill No. 2

Landfill No. 2 was used from 1900 until 1941 and is located between Commissary Road, East Street and Omaha Avenue. The actual dimensions of the site are unknown. The site was probably a fill type operation. Some burning also probably occurred. The site is closed with a soil and grass cover. According to base personnel, some hardfill was also deposited here. The site is the proposed location for a new on-base housing complex.

Landfill No. 3

Landfill No. 3 is located east of East Street and south of Crow Creek. It was used from 1941 to 1947. The site was a trench and fill

F.E. WARREN AFB
LANDFILL SITES



SOURCE: INSTALLATION DOCUMENTS

TABLE 4.3
SUMMARY OF LANDFILL DISPOSAL SITES

Landfill Designation	Period of Operation	Approximate Volume (ft^3)	Type of Waste	Method of Operation	Closure Status	Surface Drainage
No. 1	1867-1900	1,600,000	General Refuse*	Fill, some burning final cover	Closed, soil and grass cover	South to Crow Creek
No. 2	1900-1941	12,800,000	General Refuse,* Hardfill	Fill, some burning final cover	Closed, soil and grass cover	North to Crow Creek
No. 3	1941-1947	15,400,000	General Refuse,* Hardfill	Trench, fill, some burning, final cover	Closed, soil and grass cover, some subsidence	North and east to Crow Creek
No. 4	1947-1959	28,000,000	General Refuse, Hardfill, Industrial Refuse	Trench and fill some buring, final cover	Closed, soil and grass cover, extensive subsidence	South to Crow Creek
No. 5	1960-1970	16,200,000	General Refuse, Industrial Refuse, Fly Ash, Solvents, Batteries, Battery Acid	Burn pits, trench and fill, residue daily cover	Closed, soil and grass cover, extensive subsidence	North to Crow Creek West to Diamond Creek
No. 6	1971-1984	201,600,000	General Refuse, Industrial Refuse, Fly Ash, Solvents, Batteries, Battery Acid	Trench and fill daily cover	Closed for general refuse, active for fly ash, soil cover sparse vegetation	East to Diamond Creek and Crow Creek

* Includes waste from shops on base.

operation, and hardfill was deposited here after the landfill ceased operation. The site is closed with a soil and grass cover. There is some subsidence in the area. The exact location of the fill area is unknown due to extensive recontouring of the area that occurred in the late fifties.

Landfill No. 4

Landfill No. 4 was utilized by the base from 1947 until 1959. The site is located west of the Missile Drive base gate on either side of Plant Road extending from the railroad tracks on the north to Crow Creek on the south. The site was a trench and fill operation and the trenches averaged 10 feet in depth. Waste from shop dumpsters as well as housing waste was deposited in this landfill. There are unconfirmed reports of the disposal of solvents, waste oils, batteries and other industrial waste in this landfill. The landfill is closed with a soil and grass cover. There is extensive subsistence in the area of the trenches.

Landfill No. 5

Landfill No. 5 was operated from 1960 to 1970 and is located at the water tower south of the Weapons Storage Area. The site consisted of three large burn pits which were primarily for volume reduction. Refuse was deposited in Pit A on day one, burned on day two, and the residue was removed and placed in trenches on day three. The use of the burn pits was sequential and all residue was placed in trenches which were 15 to 20 feet in depth and extended for approximately 600 yards. Shop wastes as well as refuse from the housing area was deposited in this landfill. Additionally solvents, waste oils, batteries and battery acid was reportedly disposed here.

Landfill No. 6

Landfill No. 6 was used by the base from 1971 until 1984 and was a trench and fill operation. The landfill is constructed in two lifts, and approximately 60 feet in total depth. Refuse from the shops and from the base housing area was transported here on a daily basis. A daily cover was applied to the waste. The landfill was closed for refuse disposal in September 1984, and all base refuse is now transported off base to a municipal landfill. This landfill is, however, still open for disposal of coal ash. Two monitoring wells have been installed

at Landfill No. 6, and no significant contamination has been detected in the sampling and analysis which has been conducted.

Hardfill Disposal Areas

There are several areas at F. E. Warren AFB that have been used for disposal of construction rubble, brush and other hardfill. Major hardfill areas are identified in Figure 4.4. Based on interviews conducted with base personnel, review of file information, and visual observations made during the site visit, there is no evidence of any hazardous waste disposal associated with these hardfill areas.

Hardfill No. 1 located on the northwest corner of the base north of the family housing area has been used since 1941 and is still active. Some household rubbish has been deposited in this area due to its proximity to the housing area, but it was not used for regular trash disposal.

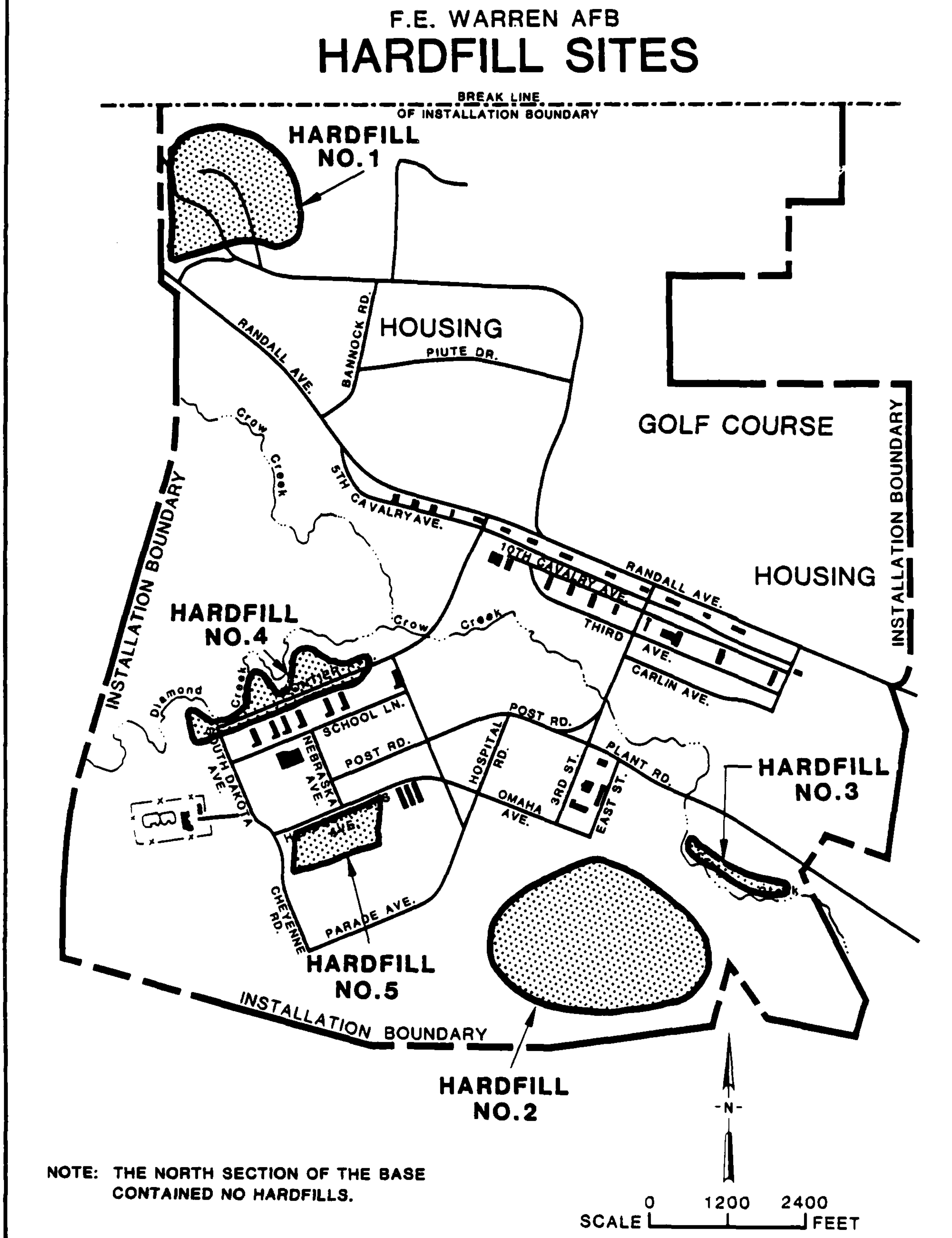
Hardfill No. 2 occupies the same site as Landfill No. 3 and was utilized in the fifties and sixties. Hardfill No. 3 is located on the southern edge of Landfill No. 4 and was operated from approximately 1958 to 1962. Hardfill area No. 4 is located between Frontier Avenue and Diamond Creek and was used from approximately 1955 until 1965. Hardfill area No. 5 is located south of Building 1250 and was used from 1952 until 1958.

Sanitary Sewerage System

Since 1942, sanitary sewage from F. E. Warren AFB has been treated at the City of Cheyenne sewage treatment plant. The collection system was expanded several times and serves the entire base with the exception of the camping area located along Crow Creek. Previous evaluation indicated that the overall condition of these systems was good. No serious operating conditions have been encountered. The sanitary sewerage was treated on base prior to 1942 when the base was connected to the city system. The location of the former sewage treatment plant is shown in Figure 4.5.

Explosive Ordnance Disposal Area

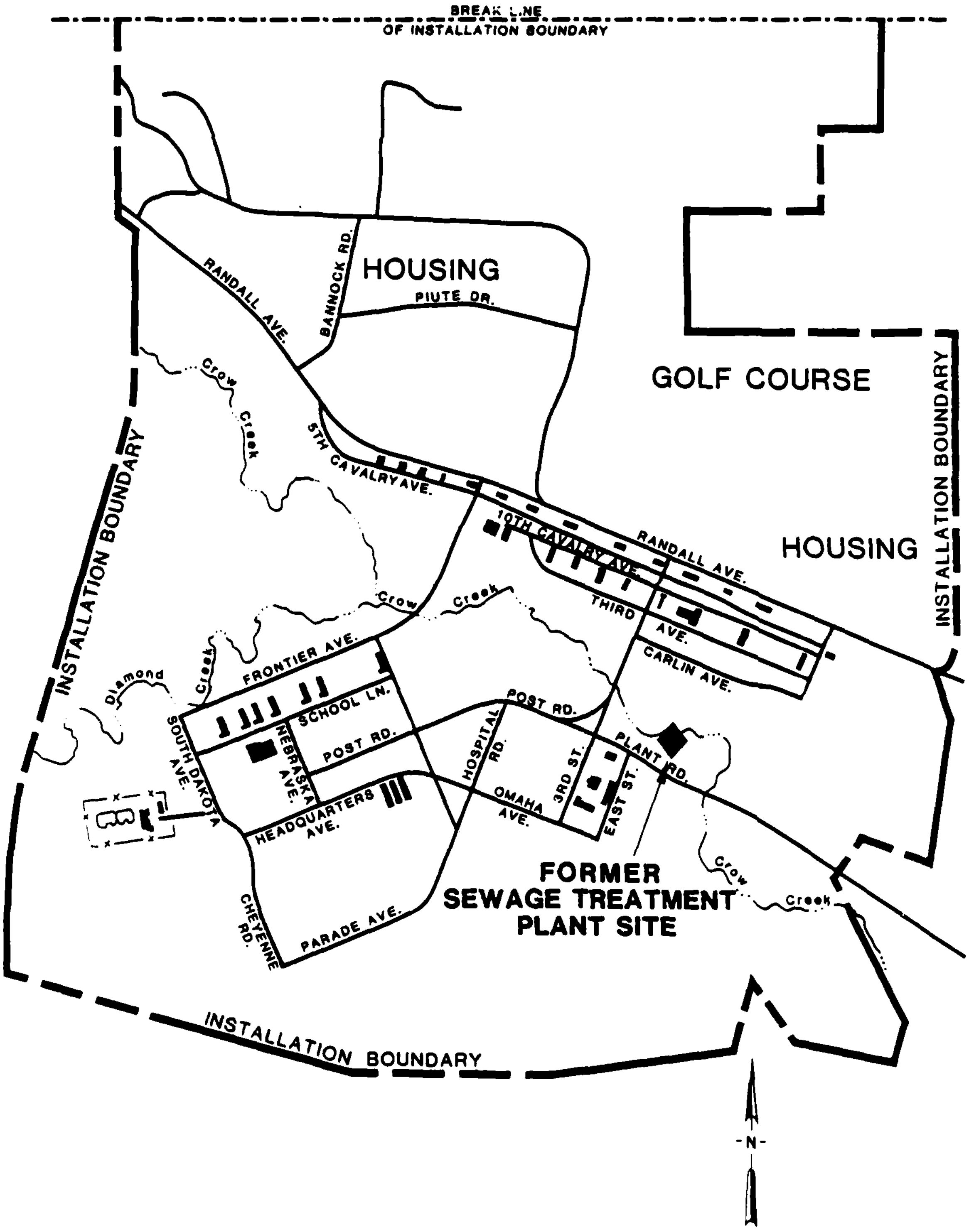
The Explosives Ordnance Disposal (EOD) (Figure 4.6) area at F. E. Warren AFB is located north of the main base area and north of Hardfill No. 1. The EOD area consists of a depressed area for detonation of active explosives and a "burn kettle" for incineration of small arms



SOURCE: INSTALLATION DOCUMENTS

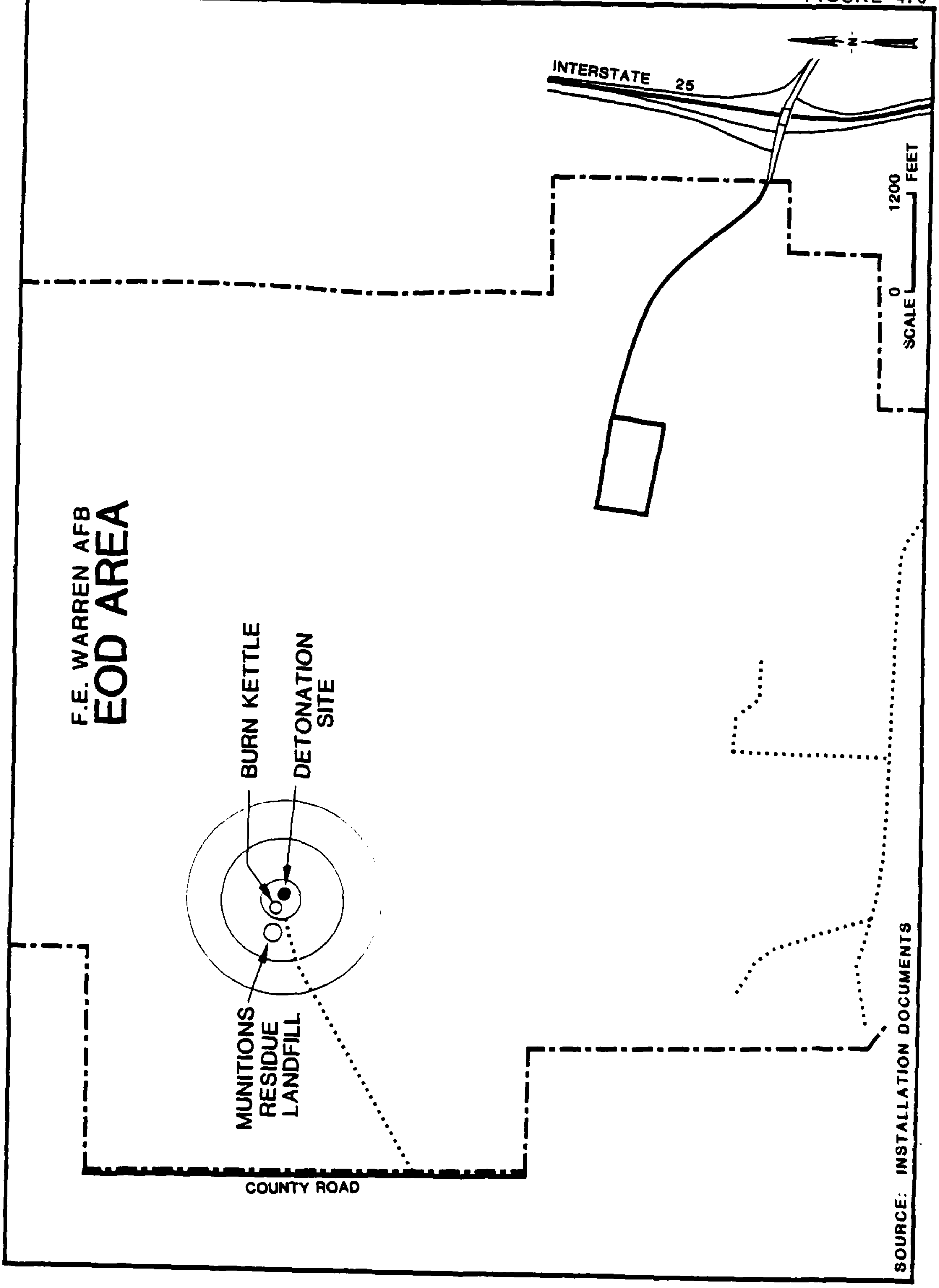
F.E. WARREN AFB

SEWAGE TREATMENT PLANT SITE



SOURCE: INSTALLATION DOCUMENTS

FIGURE 4.6


F.E. WARREN AFB
EOD AREA
INTERSTATE 25
SCALE
0
1200
FEET
BURN KETTLE
DETONATION SITE
MUNITIONS RESIDUE LANDFILL
COUNTY ROAD
SOURCE: INSTALLATION DOCUMENTS

ammunition. Detonation remains (inert material) are disposed in a munitions residue landfill immediately adjacent to the EOD area. This pit is approximately 6 feet by 20 feet in area and about 6 feet deep. One pit is currently in operation although several pits have been filled and covered.

Acid Dry Well

The acid dry well is located west of Building 826, as shown in Figure 4.7, and has been utilized since 1962 when the 90th Transporation Squadron was assigned to this facility. Waste battery acid is neutralized in a sink within Building 826 by the addition of caustic. The solution drains from Building 826 by gravity into a concrete dry well.

SATELLITE FACILITIES REVIEW

Microwave Relay Station

The microwave relay station located north of the base is one quarter acre in size and consists of an anetnna farm. The site is unmanned and no environmental impact should result from this site.

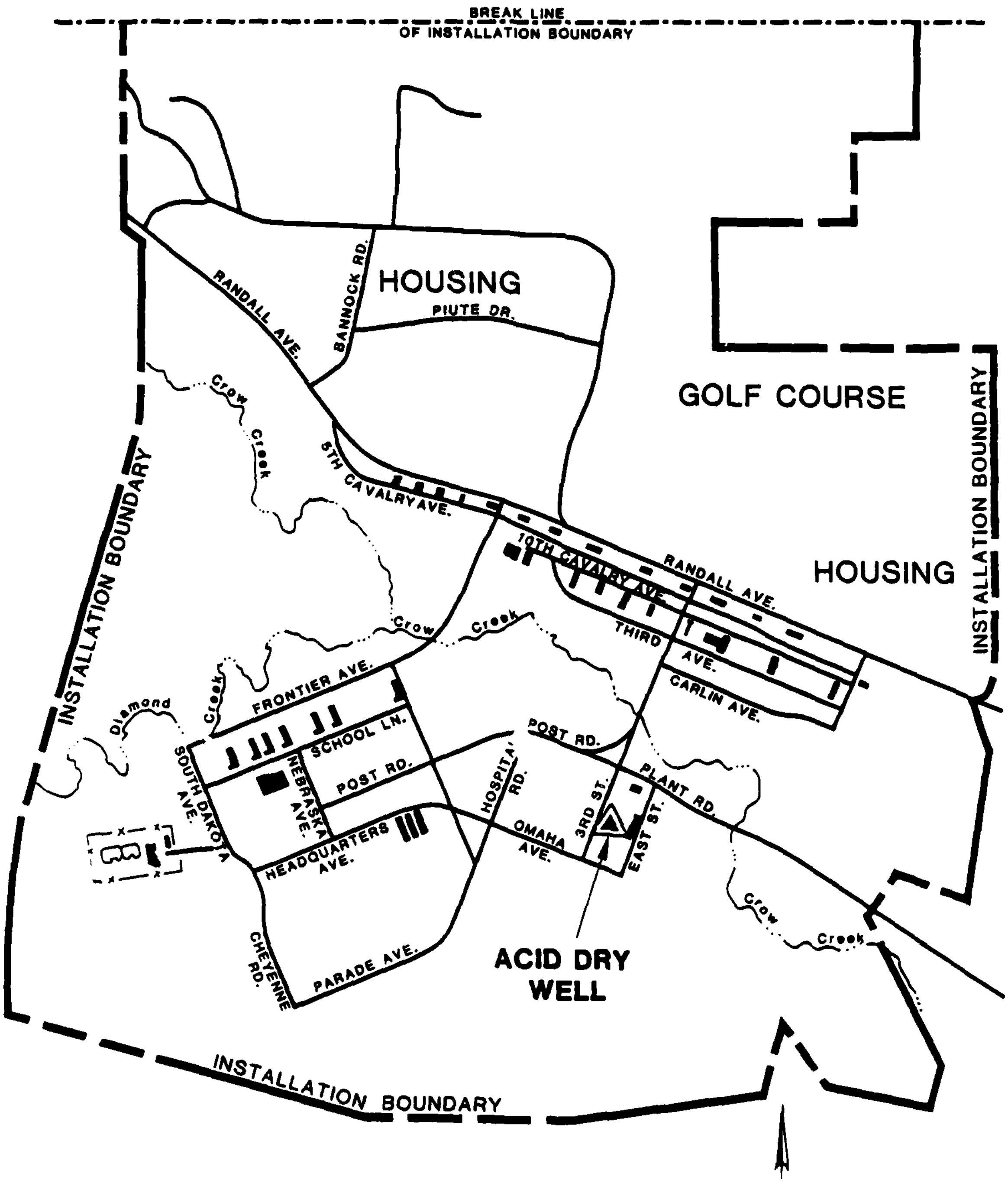
Missile Sites

The F. E. Warren AFB Missile Wing sites are located in Wyoming, Colorado and Nebraska. The Wing consists of 20 Launch Control Facilities (LCFs) and 200 Launch Facilities (LFs) for 200 Minuteman III Intercontinental Ballistic Missiles (ICBM). Each LCF controls 10 LFs. Maintenance of the LCFs and LFs is performed by the missile maintenance crew, a unit of the base Civil Engineering Squadron. Chemicals which are potentially hazardous to the environment are present at LCF and LF sites. These chemicals are described in the following paragraphs.

A main diesel fuel tank which holds 14,000 gallons of fuel is located 60 feet underground at each LCF site. The support building at each LCF has a diesel tank which contains 2,500 gallons of fuel. The main diesel tank feeds a "day tank" which holds 165 gallons of fuel and is located in the equipment bay.

An aboveground tank at each LCF holds either 1,000 or 2,000 gallons of MOGAS. Each LCF also has a 1,000 gallon underground diesel tank and a 1,000 gallon underground unleaded MOGAS tank for refueling ground equipment. A lube oil tank which contains 65 gallons of 30 weight oil is located near the generator. Ethylene glycol is used as a coolant and

F.E. WARREN AFB
ACID DRY WELL



SOURCE: INSTALLATION DOCUMENTS

Freon 502 and Freon 12 are used as refrigerants at the LCF sites. Methyl ethyl ketone (MEK) and PD-680 are used to clean the diesel fuel filters on the generators.

At the LF sites a main diesel fuel tank has a capacity of 14,500 gallons and a "day tank" holds 315 gallons. The missiles themselves are propelled with solid fuel which is not loaded or handled at these facilities. A sodium chromate solution is used in the missile guidance system for cooling; the cooling system on each missile holds 1.5 gallons of the solution. A lube oil tank near the generator holds 60 gallons of 30-weight oil. In addition, Freon 502, MEK, and PD-680 are used for the same purposes as at LCF sites. Batteries located at both LCF and LF sites are alkaline electrolyte nickel-cadmium batteries containing potassium hydroxide (KOH). Twelve lead acid batteries are located in the launchers at each site.

At each LCF and LF a sump pump is located at the base of the underground facility. At the LCF sites, the sump discharges groundwater from the capsule into a sewage lagoon on the LCF grounds. Each sewage lagoon is about fifty feet in diameter and has a depth of about five feet. The lagoons are unlined and have an overflow pipe. In addition sewage from the support building is discharged into the lagoon. At LF sites the groundwater collection sump discharge pipe is about five feet from the launch support building; the discharge runs directly onto the gravel covering the ground.

Other potential areas of contamination for both LCF and LF sites are electrical distribution transformers which may contain polychlorinated biphenyls (PCBs) and the aboveground gravelled areas, which are routinely sprayed with a weed killer during the growing season.

No problems were reported or suspected at any of the LCF or LF sites.

EVALUATION OF PAST DISPOSAL ACTIVITIES AND FACILITIES

Review of past waste generation and management practices at F. E. Warren AFB has resulted in identification of 25 sites and/or activities which were considered as areas of concern for potential contamination and migration of contaminants.

Sites Eliminated From Further Evaluation

The sites of initial concern were evaluated using the Flow Chart presented in Figure 1.2. Sites not considered to have a potential for contamination were deleted from further evaluation. The sites which have potential for contamination and migration of contaminants were evaluated using the Hazard Assessment Rating Methodology (HARM). Table 4.4 summarizes the results of the flow chart logic for each of the areas of initial concern.

Eleven of the 25 sites assessed did not warrant further evaluation. The rational for omitting these sites from HARM evaluation is discussed below. These eleven sites include:

- Five Hardfill Areas
- Landfill No. 1
- Sanitary Sewer System
- Storm Water Drainage System
- Oil/Water Separators
- EOD Area
- Missile Sites (20 LCFs and 200 LFs)

The five hardfill areas located on the base were used for disposal of construction rubble. No evidence of hazardous waste disposal was found at any of the five sites.

The remote missile sites (20 LCFs and 200 LFs) currently present no environmental threat. There have been minor incidents where discharge of oil and cleaning fluids have occurred but these quantities were very low and no significant contamination would be expected. Natural cleansing phenomena such as biodegradation would act on these low levels and prevent any accumulation of wastes.

The explosives ordnance disposal spent munitions landfills were not suspected of containing any hazardous materials. Wastes sent to this area were in an inert form and pose no environmental threat.

The oil/water separators are pumped out on an as needed basis. Effluent from the separtors drains to the sanitary sewer system. No environmental impact is expected to result from the continued operation of these separators.

TABLE 4.4
SUMMARY OF FLOW CHART LOGIC FOR AREAS OF
INITIAL HEALTH, WELFARE AND ENVIRONMENTAL CONCERN
AT F.E. WARREN AFB

Site	Potential Hazard to Health, Welfare or Environment	Need for Further IRP Evaluation/ Action	HARM Rating
Spill Site No. 1 (Building 400)	Y	Y	Y
Spill Site No. 2 (Building 810)	Y	Y	Y
Spill Site No. 3 (Building 338)	Y	Y	Y
Spill Site No. 4 (Building 1250)	Y	Y	Y
Spill Site No. 5 (Building 336)	Y	Y	Y
Spill Site No. 6 (Building 316)	Y	Y	Y
Fire Protection Training Area No. 1	Y	Y	Y
Fire Protection Training Area No. 2	Y	Y	Y
Landfill No. 1	N	N	N
Landfill No. 2	Y	Y	Y
Landfill No. 3	Y	Y	Y
Landfill No. 4	Y	Y	Y
Landfill No. 5	Y	Y	Y
Landfill No. 6	Y	Y	Y
Hardfill No. 1	N	N	N
Hardfill No. 2	N	N	N
Hardfill No. 3	N	N	N
Hardfill No. 4	N	N	N
Hardfill No. 5	N	N	N
Sanitary Sewer System	N	N	N
Stormwater Drainage System	N	N	N
Oil/Water Separators	N	N	N
Explosives Ordnance Disposal Area	N	N	N
Missile Sites (20 LF's and 200 LCF's)	N	N	N
Acid Dry Well	Y	Y	Y

Y - Yes N - No
Source: Engineering-Science

The sanitary sewer system is connected to the City of Cheyenne sanitary sewer system. It was reported that all discharge requirements are being met.

The storm drainage system drains to Crow Creek by various swales and tributaries. No environmental impact is expected to result from the continued operation of this system.

Landfill No. 1 was operated from 1867 until approximately 1900. No hazardous waste is suspected of being disposed of in this area.

Sites Evaluated Using HARM

The remaining 14 sites identified in Table 4.4 were evaluated using the Hazard Assessment Rating Methodology. The HARM process takes into account characteristics of potential receptors, waste characteristics, pathways for migration, and specific characteristics of the site related to waste management practices. Results of the HARM analysis for the sites are summarized in Table 4.5.

The procedures used in the HARM system are outlined in Appendix G and the specific rating forms for the 14 sites at F. E. Warren AFB are presented in Appendix H. The HARM system is designed to indicate the relative need for follow-on action.

TABLE 4.5
SUMMARY OF HARM SCORES FOR
POTENTIAL CONTAMINATION SITES
AT F. E. WARREN AFB

Rank	Site	Receptor Subscore	Waste Charac-teristics Subscore	Pathways Subscore	Waste Management Factor	HARM Score
1	Spill Site No. 4 (Building No. 1250)	69	80	100	1.0	83
2	Landfill No. 4	74	80	70	1.0	75
3	Landfill No. 6	72	100	50	1.0	74
4	Landfill No. 5	76	80	43	1.0	66
5	Landfill No. 2	64	60	70	1.0	65
6	Spill Site No. 1 (Building No. 400)	64	80	43	1.0	62
7	Fire Protection Training Area No. 2	64	80	35	1.0	60
8	Spill Site No. 2 (Building No. 810)	64	80	35	1.0	60
9	Acid Dry Well	64	80	35	1.0	60
10	Fire Protection Training Area No. 1	56	80	35	1.0	57
11	Landfill No. 3	72	60	35	1.0	56
12	Spill Site No. 3 (Building No. 338)	64	60	35	1.0	53
13	Spill Site No. 5 (Building No. 336)	64	60	35	1.0	53
14	Spill Site No. 6 (Building No. 316)	64	60	35	1.0	53

Source: Engineering-Science

SECTION 5
CONCLUSIONS

The goal of the IRP Phase I study is to identify sites where there is potential for environmental contamination resulting from past waste disposal practices and to assess the probability of contamination migration from these sites. The conclusions given below are based on field inspections; review of records and files; review of the environmental setting; interviews with base personnel, past employees and local, state and federal government employees; and assessments using the HARM system. Table 5.1 contains a list of the potential contamination sources identified at F.E. Warren AFB and a summary of the HARM scores for those sites. Only potential sites identified in Section 4 and determined to warrant further investigation are presented in this section.

SPILL SITE NO. 4

Spill Site No. 4 is located at Building 1250. A small spill of TCE was discovered in 1982. Subsequent cleanup and groundwater monitoring revealed groundwater contamination by TCE, PD-680 and other solvents. The 1982 spill is not thought to be solely responsible for the contamination. The base in cooperation with the Wyoming Environmental Quality Division has an on-going investigation program to locate the source of the contamination. To date, 6 monitoring wells have been installed under this investigatory program. The site represents a significant potential for environmental contamination and continued investigation is warranted. The soils in the area are composed of moderate to rapid permeable, well-drained loamy sand underlain by sand/gravel. The area has a potential for medium runoff and slight to medium erosion. Groundwater occurs at shallow depth and, therefore, presents a potential for contaminant migration in the shallow aquifer in the area. For these reasons, the site received a high HARM score of 83.

TABLE 5.1
SITES EVALUATED USING THE
HAZARD ASSESSMENT RATING METHODOLOGY
F.E. WARREN AFB

Rank	Site	Operation Period	HARM Score (1)
1	Spill Site No. 4 (Building No. 1250)	1982	83
2	Landfill No. 4	1947-1959	75
3	Landfill No. 6	1971-Present	74
4	Landfill No. 5	1960-1970	66
5	Landfill No. 2	1900-1941	65
6	Spill Site No. 1 (Building No. 400)	1973	62
7	Fire Protection Training Area No. 2	1965-Present	60
8	Spill Site No. 2 (Building No. 810)	1983	60
9	Acid Dry Well	Mid 1960's-Present	60
10	Fire Protection Training Area No. 1	1950-1965	57
11	Landfill No. 3	1941-1947	56
12	Spill Site. No. 3 (Building No. 338)	1980	53
13	Spill Site No. 5 (Building No. 336)	1962-Present	53
14	Spill Site No. 6 (Building No. 316)	1962-Present	53

(1) This ranking was performed according to the Hazard Assessment Rating Methodology (HARM) described in Appendix G. Individual rating forms are in Appendix H.

LANDFILL NO. 4

Landfill No. 4 has a significant potential for environmental contamination and follow-on investigation is warranted. The site is located west of gate No. 2 and extends from the railroad tracks on the north to Crow Creek on the south. The site was a trench and fill operation and received all base refuse (waste oil, batteries, and other shop waste) during its operation. Subsidence can be seen in the area of the trenches. The soils in the site are composed mostly of moderate to rapid permeable, well drained loamy sand underlain by sand/gravel, and to a lesser extent, moderate to rapid permeable well-drained, silty loam (Dix variety), at the extreme north of the area. The area has the potential for a slight to severe erosional activity and a relatively moderate runoff. Groundwater is expected at shallow depth at the southern portion of the site due to the close proximity to Crow Creek. The southern extent of the site also lies very close to the Crow Creek 100 year flood plain. For these reasons, the site received a slightly high HARM score of 75.

LANDFILL NO. 6

Landfill No. 6 was used by the base from 1971 until September 1984 for refuse from the housing area as well as shop waste. The site has a significant potential for environmental contamination and follow-on investigation is warranted. The site is still utilized for disposal of fly ash from the heating plant. Batteries and battery acid were reportedly deposited here as late as 1982. The site was a trench and fill operation and was constructed in two lifts, and has a maximum depth of 60 feet. The surface and subsurface soils in the area consist of loamy sand and sand/gravel with low water holding capacity and moderate to rapid permeability. These soils are underlain by a relatively thick layer of clay. The potential for runoff and erosion in the area is considered to be medium. Groundwater is assumed present at shallow depth. For these reasons, the site received a slightly high HARM score of 74.

LANDFILL NO. 5

Landfill No. 5 has a significant potential for environmental contamination and follow-on investigation is warranted. The site is located near the water tower south of the Weapons Storage Area and was operated from 1960 to 1970. The operation consisted of depositing the refuse in a pit and burning it prior to removal and ultimate deposition in adjacent trenches. Shop waste as well as waste from the housing area was deposited here on a daily basis. The trenches have subsided and the ground is cracked open in several areas. The site is closed and has a soil and grass cover. The soils in the area are composed mostly of well drained, moderate to rapid permeable, silty loam underlain by sand and gravel. A slow to moderate runoff rate is estimated in this area and erosion is determined to be severe. Groundwater is encountered at shallow depth (about 10 feet). The potential for contaminant migration into the shallow aquifer combined with other reasons mentioned resulted in a HARM score of 66 for the site.

LANDFILL NO. 2

Landfill No. 2 has significant potential for environmental contamination and follow on investigation is warranted. The site is located between Commissary Road, East Street and Omaha Avenue and was used from 1900 until 1941. The site received all waste generated at the facility and is closed with a soil and grass cover. Some hardfill was deposited here after the landfill was closed. The site is the proposed location for the new on-base housing complex. The soil in this area is composed of well drained, moderate to rapid permeable, loamy sand underlain by sand/gravel. The potential for runoff and erosion varies from slight to medium and the groundwater is present at depth less than 100 feet. These reasons contributed to a moderate HARM score of 65 for the site.

SPILL SITE NO. 1

The rupture of the leaded MOGAS tank at the service station is Spill Site No. 1. The site has a significant potential for contamination and follow-on investigation is warranted. An estimated 2,000 to 2,500 gallons of fuel was lost underground over a period of months. Gasoline vapors were detected in the NCO club which is east of the

service station. Vapors were also detected in the field east of the NCO club and the spill site. No fuel recovery was accomplished. The storage tank was excavated and replaced. The migration path of the fuel is suspected to be east toward a residential area. Surface and subsurface soils underlying the area consist of well-drained loamy sand underlain by sand/gravel which overlies a relatively thick layer of clayey soil. The loamy sand has a moderate to high permeability, and the potential for erosion and runoff varies from slight to medium in this area. For these reasons, the site received a moderate HARM score of 62.

FIRE PROTECTION TRAINING AREA NO. 2

FPTA No. 2 has been in use since 1965 and is located between Omaha Avenue and Missouri Avenue. The site has a significant potential for environmental contamination and follow-on investigation is warranted. Prior to 1974 waste oils, fuels and solvents were used in the fire training exercises. Since 1974, only clean JP-4 has been used. Presently training exercises are conducted twice per month and 300-400 gallons of fuel are consumed per exercise. Pre-wetting before adding fuel to the pit has been the standard procedure at this site. Runoff from the area is medium and it flows north toward Crow Creek. Surface and subsurface soils in the area consist of well drained loamy sand, sand/gravel and clayey soil. The loamy sand has a moderate to rapid permeability. Groundwater is present at moderate depth (less than 100 feet). For these reasons, the site received a moderate HARM score of 60.

SPILL SITE NO. 2

Spill Site No. 2 consists of a September 1983 oil spill and two waste accumulation and storage areas. In September 1983, approximately thirty 55-gallon drums containing hydraulic fluid and motor oil residues were dumped at the southern end of the lot south of Building 810. Most of the liquid ran down East Street, adjacent to the lot, and was recovered. One of the waste accumulation and storage areas is located adjacent to Building 810 and consists of a 300-gallon waste oil tank and several drums. The second area is located in the southern end of the

yard and consists of several waste oil drums. The ground around both of the waste accumulation and storage areas is stained as a result of numerous spills of oil and hydraulic fluid. Due to these three activities, Spill Site No. 2 represents a potential for environmental contamination and follow-on investigation is warranted. The soils in the site rea are composed of well drained loamy sand underlain by sand/gravel with medium to high permeability. The runoff is medium and flows towards Crow Creek. There is a potential for slight to medium erosion in this area and groundwater exist at depth less than 100 feet. In regard to these characteristics and past disposal activities, the site received a moderate HARM score of 60.

ACID DRY WELL

The acid dry well is located west of Building 826 and has a significant potential for environmental contamination and follow-on investigation is warranted. Waste battery acid (sulfuric acid) generated by the Transportation Squadron located in Building 826 was neutralized prior to discharge to the well. Surface and subsurface soils in the area consist of moderate to rapid permeable loamy sand, sand/gravel and clay. The runoff is medium and flows toward Crow Creek. The potential for erosion is slight to medium. Groundwater is present at moderate depth (less than 100 feet). For these reasons, the site received a HARM score of 60.

FIRE PROTECTION TRAINING AREA NO. 1

FPTA No. 1 was utilized from 1950 to 1965 and was located south of Crow Creek. The site has a significant potential for environmental contamination and follow-on investigation is warranted. Waste oil, fuel, and solvents were used in the fire training exercises here. The area was not pre-wet prior to training and runoff would have entered Crow Creek. The runoff rate is slow and moderate, and the potential for erosion varies from slight to severe. The site is in close proximity to the Crow Creek 100 year flood plain. Groundwater exist at moderate depth, under 100 feet. Surface and subsurface soil in the area consist of well drained, silty loam and sand/gravel with relatively moderate to

high permeability. In regard to these characteristics and past site activities, the site received a moderate HARM score of 57.

LANDFILL NO. 3

Landfill No. 3 is located east of East Street and south of Crow Creek. The site was operated from 1941 to 1947. The site has a significant potential for environmental contamination and follow-on investigation is warranted. The site was a trench and fill operation and hardfill was deposited here after the landfill was closed. The site has a soil and grass cover. The surface and subsurface soils in the area consist of well drained loamy sand and sand/gravel, with moderate to high permeability, underlain by silty to sandy clay. The runoff is medium, and relatively slight to medium erosion potential exist. Groundwater is present at moderate depth, under 100 feet. For these reasons, the site received a moderate HARM score of 56.

SPILL SITE NO. 3

Spill Site No. 3 is located west of Building 338 and has a significant potential for environmental contamination and follow-on investigation is warranted. This area was used for the disposal of used battery acid from the battery shop. At least 150 gallons of acid was deposited here in 1980. This method of disposal may also have been intermittently used prior to that time. The soils in this area consist of well drained loamy sand and sand/gravel with relatively moderate to high permeability. Silty to sandy clay is also present in this area at moderate depth. The runoff is medium and it flows south towards Crow Creek. Groundwater in the area exist at moderate depth (under 100 feet). For these reasons, the site received a low HARM score of 53.

SPILL SITE NO. 5

Spill Site No. 5 located east of Building 336 has a significant potential for environmental contamination and follow-on investigation is warranted. This is a waste oil accumulation point that has been in use since approximately 1962. There are two 200 gallon tanks as well as several 55-gallon drums of new and used oil located here. Numerous small spills have occurred and the ground in the area is heavily stained

with oil. The soils in the site area are composed of well drained loamy sand underlain by sand/gravel and silty to sandy clay at depth. In general, the loamy sand has a moderate to high permeability with slight to moderate erosion potential. The potential for runoff is medium and the direction of flow is towards Crow Creek. Groundwater is present at depth under 100 feet. In regard to these characteristics and site operation activity, the site received a low HARM score of 53.

SPILL SITE NO. 6

Spill Site No. 6 has sufficient potential for environmental contamination and follow-on investigation is warranted. The courtyard of Building 316 is used as a waste oil accumulation point by the power production shop. Although the ground has recently been covered with clean soil, numerous spills and leaks have been reported to have occurred. Prior to 1982 used battery acid was also dumped here. The yard just south of Building 316 has been used for cleaning radiators. The southern extent of the site is in close proximity to the Crow Creek 100 year flood plain and, therefore, has a flooding potential. The potential for runoff in the area is slow, and erosion is slight. The soils are well drained and consist mainly of moderate to rapid permeable loamy sand underlain by sand/gravel. Groundwater is present at depth less than 100 feet. For these reasons, the site received a low HARM score of 53.

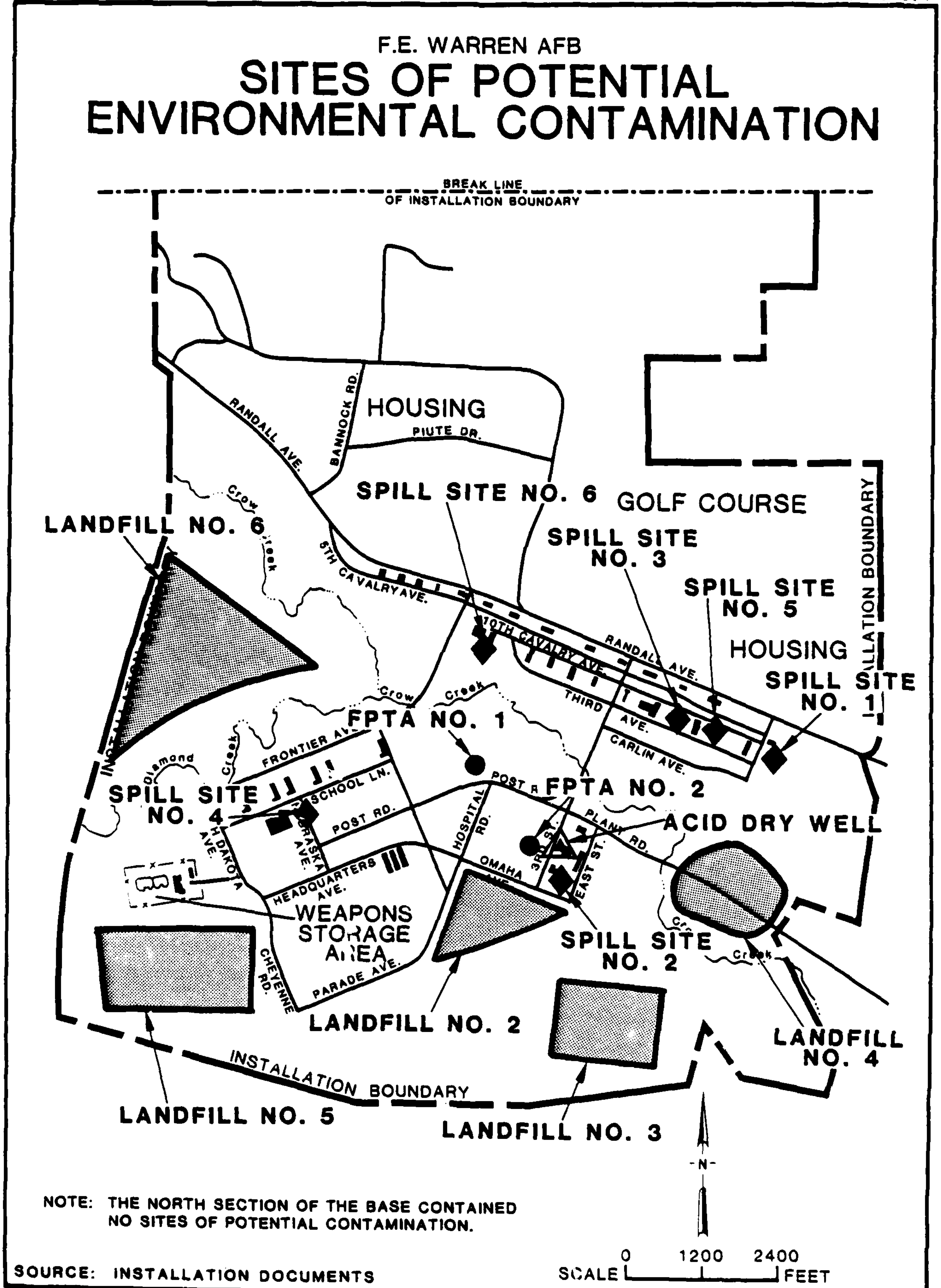
SECTION 6

RECOMMENDATIONS

Fourteen sites were identified at F.E. Warren AFB as having the potential for environmental contamination (Figure 6.1). These sites have been evaluated and rated using the HARM system which assesses their relative potential for contamination and provides the basis for determining the need for additional Phase II IRP investigations. All of the sites have sufficient potential to create environmental contamination and warrant Phase II investigations. The recommended monitoring program for Phase II is discussed, first by general monitoring rational and then by site in the following sections.

MONITORING RATIONALE

The hydrogeologic conditions present at each waste disposal facility are site-specific due to variations in geology, topography, land use modifications, etc. These conditions or man-made changes in the local environmental setting must be clearly understood in order to design an effective ground-water quality monitoring system. At present, the precise site-specific conditions existing at each of the F. E. Warren AFB waste disposal or hazardous material management facilities are unknown. Soil test borings and temporary observation wells may be employed to obtain site-specific information. A systematic, more efficient and cost-effective approach would be to utilize geophysical techniques to obtain local subsurface information. Electrical resistivity and electromagnetic conductivity are geophysical methods that employ indirect measurement technologies to collect data describing subsurface material electrical properties. The electrical resistivity and electromagnetic terrain conductivity survey instruments respond to changes or contrasts in either the horizontal or vertical planes which may be correlated to direct sampling methods, such as test borings. If local geology permits both methods may be utilized to determine stratigraphic changes, depth to ground water, aquifer thickness and contaminated zones if sufficient


F.E. WARREN AFB
SITES OF POTENTIAL
ENVIRONMENTAL CONTAMINATION
BREAK LINE
OF INSTALLATION BOUNDARY
HOUSING
BANNOCK RD.
RANDALL AVE.
PIUTE DR.
SPILL SITE NO. 6
GOLF COURSE
LANDFILL NO. 6
SPILL SITE NO. 3
SPILL SITE NO. 5
5TH CAVALRY AVE.
10TH CAVALRY AVE.
RANDALL AVE.
HOUSING
SPILL SITE NO. 1
INSTALLATION BOUNDARY
THIRD AVE.
CARLIN AVE.
Crow Creek
FPTA NO. 1
FRONTIER AVE.
SCHOOL LN.
SPILL SITE NO. 4
FPTA NO. 2
ACID DRY WELL
POST RD.
HOSPITAL RD.
PLANT RD.
3RD ST.
EAST ST.
OMAHA AVE.
HEADQUARTERS AVE.
WEAPONS STORAGE AREA
CHEYENNE RD.
PARADE AVE.
SPILL SITE NO. 2
LANDFILL NO. 2
LANDFILL NO. 4
INSTALLATION BOUNDARY
LANDFILL NO. 5
LANDFILL NO. 3
-N-
NOTE: THE NORTH SECTION OF THE BASE CONTAINED NO SITES OF POTENTIAL CONTAMINATION.
SOURCE: INSTALLATION DOCUMENTS
SCALE 0 1200 2400 FEET

contrasts exists. Electrical resistivity technique may be employed in more complicated terrains or in situations where deep contamination is suspected. Wells may then be installed systematically, in zones selected by the geophysical techniques.

This geophysical approach to monitoring program design significantly reduces both costs and schedules. The use of geophysical techniques at waste disposal facilities has been well documented in the technical literature. A U.S. Environmental Protection Agency guidance manual describes the capabilities and limitations of electrical resistivity at waste disposal facilities and is applicable to the probable conditions that may be encountered at F.E. Warren AFB (Benson, et al., 1984 and USEPA, 1978). Other geophysical methodologies can be utilized for specialized purposes-for example, a metal detector may be used in shallow settings to locate buried ferrous materials and the magnetometer may be utilized to locate either buried metal objects or distrubed zones (backfilled trenches or pits) in shallow and deep settings.

Ground-water quality monitoring systems must be designed for the site-specific conditions existing at a waste disposal facility. Guidelines for well system design have been published in several USEPA reports. One report indicates that a few guidelines are applicable to conditions such as those noted at F.E. Warren AFB. For large areas, landfills, or for areas for multiple ground-water flow directions, it is recommended that more than the usual four wells (one upgradient and three downgradient, from RCRA, Subpart F, Section 265.91, "Ground-Water Monitoring system") may be required. Where multiple flow directions may exist beneath a site, geophysical methods should be utilized for well placement, both the physical location and the screened interval.

While soil boring and well installation is being performed, readings, with an organic vapor analyzer (OVA) or similar equipment should be made. Such equipment can be used as a screening device to determine those soil samples to be put aside for chemical analyses and can also be used as a health and safety device for the protection of the field crew from potentially harmful organic vapors.

Those sites with a potential for ground-water contamination should be monitored with 4-inch diameter wells consisting of Schedule 40 PVC screens and casing with threaded joints. Screens should be placed 20

feet into the saturated thickness of the uppermost or watertable aquifer. If the initial ground-water samples indicate contamination, additional wells may be required. The number of wells may be reduced if the geophysical techniques are successful in identifying subsurface leachate plumes.

RECOMMENDED PHASE II MONITORING

The recommendations in this section are made to further assess the potential for environmental contamination from waste disposal areas at F.E. Warren AFB. The recommended actions are sampling and monitoring programs to determine if contamination does exist at the site. If contamination is identified in this first-step investigation, the Phase II sampling program will probably need to be expanded to define the extent and type of contamination. The recommendations are summarized in Table 6.1 and 6.2.

Spill Site No. 4

Spill Site No. 4, the Building 1250 TCE spill, has been identified as a site of environmental contamination and continued monitoring is recommended. Additional groundwater monitoring wells may be required in order to identify the source of contamination and the lateral and vertical extent of the contaminant plume. Since TCE is more dense than water, additional wells to identify the vertical migration are recommended. At a minimum, deeper wells should be installed adjacent to the existing wells No. 1 and 2. The new wells should have a screened interval from a depth of ten to twenty feet below the bottom of the screened interval in existing wells No. 1 and 2, and be sealed from the surface to the top of the screen. An Organic Vapor Analyzer (OVA) should also be used during well installation. After the general area of the contamination source has been identified with the groundwater monitoring wells, eight or ten soil borings are recommended to find the specific source and/or the extent of contaminated soils. The borings should be extended to a depth of approximately 20 feet, and an OVA should be used during the borings to determine the areas of high organic contamination. Samples should be collected at high OVA readings in order to identify the contaminant. The groundwater and soil samples should be analyzed for the parameter listed in Table 6.2, List B.

TABLE 6.1
RECOMMENDED MONITORING PROGRAM FOR PHASE II IRP
AT F.E. WARREN AFB

Site	Rating Score	Recommended Monitoring	Samp. Analysis List*	Comments
Spill Site No. 4 (Building 250, TCE Spill)	83	Continue investigation, including additional wells, to locate source. Consider at least two additional deep wells to determine the vertical extent of contamination. Conduct test borings, using Organic Vapor Analyzer (OVA) to determine the exact source location and/or the extent of contaminated soils.	B	Additional monitoring wells and borings may be necessary to assess the horizontal and vertical extent of contamination, and to identify the source.
Landfill No. 4	75	Use geophysics to assist in determining size and location of landfill. Install and sample 1 upgradient and 3 downgradient wells. Use OVA during well installation.	A	If sampling indicates contamination, continue monitoring. Additional wells and soil samples may be necessary to assess extent of contamination.
Landfill No. 6	74	Use geophysics to assist in determining size and location of landfill. Install and sample 1 upgradient and 4 downgradient wells. Use OVA during well installation.	A	If sampling indicates contamination, continue monitoring. Additional wells and soil samples may be necessary to to assess extent of contamination.
Landfill No. 5	66	Use geophysics to assist in determining size and location of landfill. Install and sample 1 upgradient and 3 downgradient wells. Use OVA during well installation.	A	If sampling indicates contamination, continue monitoring. Additional wells and soil samples may be necessary to assess extent of contamination.
Landfill No. 2	65	Use geophysics to assist in determining size and location of landfill. Install and sample 1 upgradient and 3 downgradient wells. Use OVA during well installation.	A	If sampling indicates contamination, continue monitoring. Additional wells and soil samples may be necessary to assess extent of contamination.
Spill Site No. 1 (Building 400, Service Station)	62	Install and sample 1 upgradient and 3 downgradient wells. Consider use of existing wells. Use OVA during well installation.	B	If sampling indicates contamination, monitoring wells and additional borings may be necessary to assess extent of contamination.

*See Table 6.2

TABLE 6.1
(CONTINUED)
RECOMMENDED MONITORING PROGRAM FOR PHASE II IRP
AT F.E. WARREN AFB

Site	Rating Score	Recommended Monitoring	Sample Analysis List	Comments
Fire Protection Training Area No. 2	60	Preform 3 soil borings to 20 feet. Use OVA during borings. Take soil samples at 2 ft intervals and high OVA readings.	A	If sampling indicates contamination, monitoring wells and additional borings may be necessary to assess extent of contamination.
Spill Site No. 2 (Building 810, Accumulation Point)	60	Preform 5 soil borings to 20 feet. Use OVA during borings. Take soil samples at 2 ft intervals and high OVA readings.	B	If sampling indicates contamination, monitoring wells and addi ional borngs may be necessary to assess extent of contamination.
Acid Dry Well (Building 826)	60	Use geophysics to assist in determining size and location of spill. Conduct 3 soil borings to 20 feet. Collect soil samples at 2 ft intervals.	C	If sampling indicates contamination, monitoring wells and additional borings may be necessary to assess extent of contamination.
Fire Protection Training Area No. 1	57	Preform 3 soil borings to 20 feet. Use OVA during borings. Take soil samples at 2 ft intervals and high OVA readings.	A	If sampling indicates contamination, monitoring wells and additional borings may be necessary to assess extent of contamination.
Landfill No. 3	56	Use geophysics to assist in determining extent of landfill. Install and sample 1 upgradient and 3 downgradient wells. Use OVA during well installation.	A	If sampling indicates contamination, continue monitoring. Additional well and soil samples may be necessary to assess the extent of contamination.
Spill Site No. 3 (Building 338, Acid Spill)	53	Use geophysics to assist in determining size and location of spill conduct 2 soil borings to 20 feet. Collect soil samples at 2 ft intervals.	C	Continue monitoring. Additional wells and soil samples ples may be necessary to determine the extent of contamination.

TABLE 6.1
(CONTINUED)
RECOMMENDED MONITORING PROGRAM FOR PHASE II IRP
AT F.E. WARREN AFB

Site	Rating Score	Recommended Monitoring	Sample Analysis List	Comments
Spill Site No. 5 (Building 336, Accumulation Point)	53	Preform 2 soil borings to 20 feet. Use OVA during borings. Take soil samples at 2 ft intervals and high OVA readings.	B	If sampling indicates contamination, monitoring wells and additional borings may be necessary to ssess extent of contamination.
Spill Site No. 6 (Building 316, Accumulation Point)	53	Preform 4 soil borings to 20 feet. Use OVA during borings. Take soil samples at 2 ft intervals and high OVA readings.	B	If sampling indicates contamination, monitoring wells and additional borings may be necessary to asess extent of contamination.

TABLE 6.2
RECOMMENDED LIST OF ANALYTICAL PARAMETERS FOR PHASE II IRP
AT F.E. WARREN AFB

Parameters	Method Number: Waters	Method Number: Soils
List A		
pH (water samples only)	EPA 150.1	No soils
Oil and grease	EPA 413.2	EPA 3550 then EPA 413.2
Volatile organics	EPA 624	SW 8240
EP Toxicity - metals Only (soil samples only)	No waters	SW 8240 then 40 CFR, 261.24
Metals scan (Water samples only)	EPA 200.7	No soils
Lead (water samples only)	EPA 239.2	No soils
Mercury (water samples only)	EPA 245.1	No soils
List B		
pH (water sample only)	EPA 150.1	SW 9040
Oil and grease	EPA 413.2	EPA 3550 then EPA 413.2
Volatile organics	EPA 624	SW 8240
Lead	EPA 239.2	SW 3010 then SW 7420
List C		
pH	No waters	SW 9040
Metals scan	No waters	SW 6010
Lead	No waters	SW 3060 then SW 7420
Sulfates	No waters	EPA 375.2

Notes: EPA - EPA Manual 600/4-82-057
SW - EPA SW Manual 846, 2nd Edition

Source: Engineering-Science

Landfill No. 4

Landfill No. 4 has a potential for environmental contamination and monitoring of the site is recommended. Geophysics should be utilized to determine the physical size of the area and to locate any leachate plumes which may be present. Using the geophysical measurements as a guide, one upgradient and three downgradient wells should be installed. An OVA should be used during well installation. The wells should be installed such that the screen extends one foot above the seasonal high water table to enable floating organics which may be present to enter the well. The water samples should be analyzed for the parameters listed in Table 6.2, List A.

Landfill No. 6

Landfill No. 6 has a potential for environmental contamination and monitoring of the site is recommended. Geophysics should be utilized to determine the physical size of the area and to locate any leachate plumes which may be present. Using the geophysical measurements as a guide, one upgradient and four downgradient wells should be installed. An OVA should be used during well installation. The wells should be screened such that the screen extends one foot above the seasonal high water table to enable floating organics which may be present to enter the well. The existing wells at the site should be examined to determine their suitability for inclusion in the monitoring program. Water samples taken from the monitoring wells should be analyzed for the parameters listed in Table 6.2, List A.

Landfill No. 5

Landfill No. 5 has a potential for environmental contamination and monitoring of the site is recommended. Geophysics should be used to determine the physical size of the area and to locate any leachate plumes which may be present. Using the geophysical measurements as a guide, one upgradient and three downgradient wells should be installed. An OVA should be used during well installation. The wells should be screened such that the screen extends one foot above the seasonal high water table to enable floating organics which may be present to enter the well. The water samples should be analyzed for the parameters listed in Table 6.2, List A.

Landfill No. 2

Landfill No. 2 has a potential for environmental contamination and monitoring of the site is recommended. Geophysics should be used to determine the physical size of the area and to locate any leachate plumes which may be present. Using the geophysical measurements as a guide, one upgradient and three downgradient wells should be installed. An OVA should be used during well installation. The wells should be screened such that the screen extends one foot above the seasonal high water table to enable floating organics which may be present to enter the well. The water samples should be analyzed for the parameters listed in Table 6.2, List A.

Spill Site No. 1

Spill Site No. 1 has a potential for environmental contamination and monitoring of the site is recommended. In order to determine the extent of contamination, one upgradient and three downgradient wells should be installed and sampled. An OVA should be used during well installation. The existing wells at the site should be examined to determine their suitability for inclusion in the monitoring program. The groundwater samples should be analyzed for the parameters listed in Table 6.2, List B.

Fire Protection Training Area No. 2

Fire Protection Training Area No. 2 has a potential for environmental contamination and monitoring of this site is recommended. Three soil borings should be conducted within the burn area where visual observation shows gross contamination. Selected soil samples from these borings should be analyzed for the parameters listed in Table 6.2, List A. If soil contamination is confirmed additional soil borings may be required to determine the extent of the contamination. An OVA should be used during the boring procedure. The borings should terminate at 20 feet below land surface and samples should be taken every 2 feet and at high OVA readings. If soil contamination is confirmed additional borings and/or monitoring wells may be required to determine the extent of the contamination.

Spill Site No. 2

Spill Site No. 2 has a potential for environmental contamination and monitoring of the site is recommended. A minimum of five soil bor-

borings should be made at the site. Two of the soil borings should be made at the waste oil accumulation tank located at the north end of the lot south of Building 810. Three borings should be located in the southeast corner of the Building 810 lot in the area of the accumulation point and the September 1983 spill. All borings should extent to a depth of 20 feet, and an OVA should be utilized during the boring process. A probe should be made to determine the type of construction material that was used to form the bottom of the waste oil tank dike. Soil samples should be taken at two foot intervals and at high OVA readings. The samples should be analyzed for the parameter listed in Table 6.2, List B.

Acid Dry Well

The acid dry well has a potential for environmental contamination and monitoring of the site is recommended. Geophysics should be utilized to assist in determining the size of the spill site and to locate any contamination plume which may be present. Using the geophysics as a guide, three soil borings should be made in the area of suspected contamination. The borings should extend to a depth of 20 feet. Soil samples should be collected every two feet and analyzed for lead and sulfates. Additionally a continuous soil sample should be taken from land surface to a depth of two feet. This sample should be divided into six inch sections and each section should be analyzed for the parameters listed in Table 6.2, List C.

Fire Protection Training Area No. 1

Fire Protection Training Area No. 1 has a potential for environmental contamination and monitoring of this site is recommended. Three soil borings should be conducted within the burn area where visual observation shows gross contamination. Selected soil samples from these borings should be analyzed for the parameters listed in Table 6.2, List A. If soil contamination is confirmed additional soil borings may be required to determine the extent of the contamination. An OVA should be used during the boring procedure. The borings should terminate at 20 feet below land surface and samples should be taken every 2 feet and at high OVA readings. If soil contamination is confirmed additional borings and/or monitoring wells may be required to determine the extent of the contamination.

Landfill No. 3

Landfill No. 3 has a potential for environmental contamination and monitoring of the site is recommended. Geophysics should be utilized to determine the physical size of the area and to locate any leachate plume which may be present. Using the geophysical measurements as a guide one upgradient and three downgradient wells should be installed. An OVA should be used during well installation. The wells should be screened such that the screen extends one foot above the seasonal high water table to enable floating organics which may be present to enter the well. Water samples should be analyzed for the parameters listed in Table 6.2, List A.

Spill Site No. 3

Spill Site No. 3, the acid spill site west of Building 338, has a potential for environmental contamination and monitoring of the site is recommended. Geophysics should be utilized to determine the location of the spill using the geophysics as a guide, two soil borings should be made to a depth of 20 feet. The first two feet of boring should be continuously sampled and the core divided into four equal sections for analysis. Additional soil samples should be taken at two foot intervals all soil samples should be analyzed for the parameters listed in Table 6.2, List C.

Spill Site No. 5

Spill Site No. 5, the accumulation point east of Building 336, has a potential for environmental contamination and monitoring of the site is recommended. Two soil borings should be made within the oil storage accumulation area where visual observation reveals gross soil contamination. The borings should extend to a depth of 20 feet. An OVA should be used during the boring process. Soil samples should be taken at two foot intervals and at high OVA readings. All soil samples should be analyzed for the parameters listed in Table 6.2, List B.

Spill Site No. 6

Spill Site No. 6, the Building 316 courtyard and south yard, has a potential for environmental contamination and monitoring of the site is recommended. Four soil borings should be made and should extend to a depth of 20 feet. Two soil borings should be taken in the Building 316 courtyard and two others in the yard south of Building 316. An OVA

should be used duing the boring process. Soil samples should be analyzed for the parameters listed in Table 6.2, List B.

TABLE OF CONTENTS
APPENDICES

		Page No.
APPENDIX A	BIOGRAPHICAL DATA	
	E. J. Schroeder	A-1
	D. A. Palombo	A-3
	R. D. Stephens	A-5
	J. P. McAuliffe	A-7
APPENDIX B	LIST OF INTERVIEWEES AND OUTSIDE AGENCY CONTACTS	
	List of Interviewees	B-1
	Outside Agency Contacts	B-4
APPENDIX C	TENANT ORGANIZATIONS AND MISSIONS	C-1
APPENDIX D	SUPPLEMENTAL BASE FINDINGS INFORMATION	D-1
APPENDIX E	MASTER LIST OF SHOPS	
	90th Field Missile Maintenance Squadron	E-1
	90th Civil Engineering Squadron	E-1
	90th Transportation Squadron	E-2
	90th Combat Support Group	E-3
	90th Organizational Missile Maintenance Squadron	E-3
	Detachment 10, 37th Aerospace Rescue and Recovery Squadron	E-3
	USAF Hospital, F. E. Warren	E-4
	2149th Informations Systems Squadron	E-4
	Army and Air Force Exchange Services	E-5
	Ogden Air Logistics Center	E-5
APPENDIX F	PHOTOGRAPHS	F-1
APPENDIX G	USAF INSTALLATION RESTORATION PROGRAM HAZARD ASSESSMENT RATING METHODOLOGY	G-1

TABLE OF CONTENTS
(continued)

APPENDIX H	SITE HAZARD ASSESSMENT RATING FORMS	
	Spill Site No. 4	H-1
	Landfill No. 4	H-3
	Landfill No. 6	H-5
	Landfill No. 5	H-7
	Landfill No. 2	H-9
	Spill Site No. 1	H-11
	FPTA No. 2	H-13
	Spill Site No. 2	H-15
	Acid Dry Well	H-17
	FPTA No. 1	H-19
	Landfill No. 3	H-21
	Spill Site No. 3	H-23
	Spill Site No. 5	H-25
	Spill Site No. 6	H-27
APPENDIX I	GLOSSARY OF TERMINOLOGY AND ABBREVIATIONS	I-1
APPENDIX J	REFERENCES	J-1
APPENDIX K	INDEX OF REFERENCES TO POTENTIAL CONTAMINATION SITES AT F. E. WARREN AFB	K-1

APPENDIX A

BIOGRAPHICAL DATA

Biographical Data

ERNEST J. SCHROEDER

Environmental Engineer
PII Redacted Manager, Solid and Hazardous Waste Dept.

[redacted]

Education

B.S. in Civil Engineering, 1966, University of Arkansas, Fayetteville, Arkansas
M.S. in Sanitary Engineering, 1967, University of Arkansas, Fayetteville, Arkansas

Professional Affiliations

Registered Professional Engineer (Arkansas No. 3259, Georgia No. 10618, and Texas No. 33556)
Water Pollution Control Federation
American Academy of Environmental Engineers

Honorary Affiliations

Chi Epsilon

Experience Record

1967-1976 Union Carbide Technical Center, Engineering Department, South Charleston, West Virginia (1967-1968). Project Engineer. Responsible for environmental protection engineering projects for various organic chemicals and plastics plants.

Union Carbide Corporation, Environmental Protection Department, Texas City, Texas (1969-1975). Project Engineer and Engineering Supervisor. Responsible for various aspects of plant pollution abatement programs, including preparation of state and federal permits for wastewater treatment activities, operations representative on $8 million regional wastewater treatment project (process design, detailed design, construction and startup), and supervisor for operation of wastewater collection and treatment facilities.

Union Carbide Corporation, Environmental Protection Project Engineer, Toronto, Ontario, Canada (1975-1976). Responsible for the environmental permitting and engineering design of waste treatment systems associated with a new refinery.

Ernest J. Schroeder (Continued)

1976-Date Engineering-Science, Inc., Project Manager (1976-1978). Engineering and project management of various industrial wastewater and hazardous waste projects.

Engineering-Science, Inc., Manager of the Industrial Waste Group in the Atlanta, Georgia office (1978-1980). Responsible for the supervision of industrial waste project managers and project engineers and the management of industrial waste studies conducted in the office. Also directly involved in project management consulting with clients on environmental studies and environment assessment projects, e.g., project manager for several spill control and wastewater treatability projects and for a third-party EIS for a new phosphate mine in Florida.

Engineering-Science, Inc., Manager of Solid and Hazardous Waste Group in the Atlanta, Georgia office (1980-date). Responsible for the supervision of solid and hazardous waste project managers and project engineers and the management of solid and hazardous waste projects in the office. Project activities have included permit and regulatory assistance, environmental audits, waste management program development, delisting partitions, ground-water monitoring, landfill evaluations, landfill closure design, hazardous waste management, waste inventory, waste recovery/recycle evaluation, waste disposal alternative evaluation, transportation evaluation, and spill control and countermeasure planning, HRS evaluations, preparation of remedial investigations and feasibility studies, and design and construction supervision for hazardous waste site cleanup.

Project Manager for fourteen Phase I Installation Restoration Program projects for the U.S. Air Force. The objective of this program is to audit past hazardous waste disposal practices that could result in migration of contaminants and recommend priority sites requiring further investigation. Also conducted environmental audits (air, water and solid waste) at ten industrial facilities. Project manager for a contamination assessment and hazardous waste site cleanup conducted for an industrial client as part of a consent decree agreement. Project manager for site investigation and contamination assessment projects at multiple hazardous waste sites in the northeast. Project manager for preparation of two Remedial Investigation/Feasibility Studies.

Biographical Data

DENNIS A. PALOMBO

PII Redacted

Senior Hydrogeologist

[redacted]

Education

B.S. in Geology, 1972, Bowling Green State University, Bowling Green, Ohio
M.S. in Hydrogeology, 1974, Ohio State University, Columbus, Ohio

Professional Affiliations

Association of Groundwater Scientists and Engineers
American Institute of Professional Geologists (No. 6277)

Experience Record

1974-1977 Moody and Associates, Inc., Environmental Services Division, Meadville, Pennsylvania. Hydrogeologist. Performed field work and data analysis for regional and site-specific hydrogeologic studies involving water supply, sanitary landfills, hydrocarbon contamination of groundwater, and water quality management. Conducted surface geophysical investigations for water supply and water quality studies.

1977-1978 Michael Baker, Jr., Inc., Geotechnical Engineering Department, Beaver, Pennsylvania. Hydrogeologist. Conducted municipal and industrial groundwater supply potential investigations. Planned and coordinated geotechnical field studies related to sanitary landfills, impoundments, and other site-specific hydrologic problems. Served as a principal investigator on EPA demonstration project and on proposals for geologic and hydrologic studies. Conducted geophysical investigations for development of groundwater supplies.

1978-1980 Rockwell Hanford Operations, Research Department, Richland, Washington. Senior Hydrologist and Work Unit Manager for site's major unconfined aquifer program. Responsible for planning, location, conduct, and coordination of drilling and aquifer testing activities within the Hanford site's unconfined aquifer. Duties included detailed characterization of hydrogeologic aspects of groundwater flow and radionuclide migration, hydraulic property determination, and long-term groundwater monitoring within the chemical separation areas.

1980-1983 Engineering-Science. Senior Hydrogeologist. Responsible for over 50 groundwater studies and investigations related to hazardous wastes disposal, land disposal of municipal and industrial wastes, municipal and industrial water supply.

Dennis A. Palombo (Continued)

Duties include assuring corporate level quality control on the geologic and hydrogeologic aspects of site-specific and regional projects. Designed and implemented many RCRA groundwater monitoring programs at hazardous waste disposal sites. Sites included contamination by petroleum products, heavy chlorinated solvents, metals, radionuclides, complex organics.

Developed the following government approved programs for industry and military installations: closure plans for abandoned hazardous waste disposal sites; partial waiver demonstrations of RCRA groundwater monitoring requirements; design of aquifer rehabilitation programs at several sites; subsurface data collection studies for new waste disposal sites; design of hazardous waste landfills; groundwater quality assessment programs.

1984 Acres International Corporation, Buffalo, New York. Senior Hydrogeologist. Duties included the development of technical work plan and quality assurance plan for a Superfund site. Health and safety training for hazardous waste work. Development of computer analytical modeling capabilities for groundwater flow and transport simulations. Developed contingency and remediation plans for flyash landfill in New York State.

Present Engineering-Science, Cleveland, Ohio. Senior Hydrogeologist. Responsible for environmental characterization at waste management sites at U.S. Air Force Installations. Responsible for technical aspects of hydrogeologic data collection and aquifer rehabilitation at active and inactive industrial hazardous waste sites across the country.

Publications and Presentations

"Groundwater Monitoring Programs", presented at First National Hazardous Waste Conference, sponsored by the Engineering and Science Research Foundation, Chicago, Illinois, April 1981

"Chlorinated Hydrocarbon Monitoring in a Groundwater Environment, Proceedings of National Conference on Management of Uncontrolled Hazardous Waste Sites, Hazardous Materials Control Research Institute, Silver Spring, Md., 1982 (Co-Author J.H. Jacobs)

"Principals of Hydrogeology", in Reference Handbook for Hazardous Waste Management, Engineering and Science Research Foundation, Arcadia, California, 1980

Biogr'phical Data

ROBERT D. STEPHENS
Environmental Scientist

PII Redacted

[redacted]

Education

B.A. Biology - 1971, Berea College, Berea Kentucky
Graduate Studies, Environmental Engineering 1973-1974, University of Cincinnati, Cincinnati, Ohio

Professional Affiliations, Honors and Awards

Air Pollution Control Association
Water Pollution Control Federation

Experience Record

1971-1973 Kentucky Department of Health Air Pollution Control Group, Regional Manager of a nine county region in northern Kentucky. Responsible for enforcement of State Air Reglations, Air Monitoring and Public Liason.

1973-1974 Envirico, Covington, Kentucky. Operated as a consultant in Air Pollution Control, OSHA Programs, Water Pollution Control and Solid Waste Disposal. Projects included asbestos waste disposal, and waste disposal from a drum recycling plant.

1974-1977 Pedco Environmental Specialists, Cincinnati, Ohio served as chief technical investigator on various contracts dealing with air pollution control and management.

1977-1978 Florida Department of Environmental Regulation, Environmental Specialist, provided technical support to Enforcement Group on various air pollution problems.

1978-1984 Mobil Chemical Company.

1978-1981, Manager Environmental Permitting, South Fort Meade Project Nichols, Florida. Structured, staffed and directed an environmental permitting effort and obtained required federal permits for an 18,000 acre grassroots phosphate mine. Waste disposal planning activities were a major part of the project.

Robert D. Stephens (Continued)

1981-1983, Manager Environmental Control, Phosphorus Division Richmond, Virginia. Responsible for the Environmental Integrity of 27 operating units at 11 plant locations throughtout the U.S. Designed, conducted and managed environmental studies to modify NPDES permit requirements for phosphoric acid production facility. Designed, implemented, and managed a program to conduct environmental audits of division plants. Planned and executed an investigation of subsurface site conditions at a major phosphorus chemical production facility. Initial findings of pesticide contamination in the area resulted in a study expansion to assess affects of specific pesticide residues in the biological community and the ultimate impact on humans.

1983-1984, Manager Environmental Control Chemical Products Richmond, Virginia. Responsible for Environmental Integrity of 50 operating units at 27 plant locations throughout the U.S. Directed preparation of a "Part B" Hazardous Waste Permit Application for a major phosphorus-based chemical operation in South Carolina. Instituted novel approach resulting in approval of application without modification by regulatory authorities. Planned and executed the environmental program which resulted in official sanction of phospho-gypsum, a hazardous waste in Texas, as an environmentally acceptable aggregate within the State of Texas. Approvals received from Texas Board of Health, Bureau of Radiation control, Texas Department of Water Resources, and Texas Air Control Board. Planned and executed a program to obtain a variance to state and federal water pollution control laws to allow continued operation of a fertilizer intermediates plant and the leaking waste gypsum pond associated with the plant. Provided expert testimony in this environmental litigation.

1985-Date Engineering-Science. Project Engineer, responsible for hazardous waste site assessment studies conducted for industry and Department of Defense.

Publications

"Water Quality in Rural Madison County," Kentucky Department of Health, Division of Sanitary Engineering, 1971

"Evaluation of the Mobil Ground Water Assessment Protocol at the Mobil Chemical Company, Charleston, S.C. Plant Site," Mobil Chemical Company, Phosphorus Division, 1983

"Biological Studies on Paddys Run Creek, Fernald, Ohio," Mobil Chemical Company, Chemical Products Division, 1984

Biographical Data

JOHN P. MCAULIFFE

Environmental Engineer

PII Redacted

[redacted]

Education

M.S. in Civil and Environmental Engineering, 1982, Clarkson College of Technology, Potsdam, NY
B.S. in Civil and Environmental Engineering, 1981, Clarkson College of Technology, Potsdam, NY (Graduated with Distinction)

Professional Affiliations

Engineer-in-training, New York State
Water Pollution Control Federation

Honorary Affiliations

Chi Epsilon
Tau Beta Pi

Experience Record

1981-1982 Clarkson College of Technology, Potsdam, New York. Research/Teaching Assistant. Conducted biological assays and chemical characterizations on Lake Erie Tributary sediments to evaluate changes in the availability of phosphorus due to exposure to anaerobic conditions. Responsibilities included compiling data and formulating conclusions for submittal to the U.S. Army Corps of Engineers and preparation of Masters Thesis. Teaching responsibilities included preparation of course materials and assisting with laboratory classes.

1982-1985 O'Brien & Gere Engineers, Inc., Syracuse, New York. Environmental Engineer. As a project engineer, performed environmental engineering on a variety of projects involving hazardous waste site investigations and remediation designs, groundwater contamination investigations and remediation designs, and industrial/municipal wastewater treatment studies. Specific projects included:

John P. McAuliffe (Continued)

engineering support for litigative defense in a CERCLA (Superfund) laswsuit at four Central Indiana industrial waste sites; design and implementation of preliminary remedial measures at two Superfund sites; remedial investigation/feasibility study at Central New York Superfund site; site remediation programs at seven New York State PCB disposal sites; coordination of an industrial wastewater characterization study; and design and permits for water treatment plant sludge disposal facility.

1985-Present Engineering-Science, Inc., Syracuse, NY. Environmental Engineer. Project Engineer responsible for various activities within the hazardous waste field. Primary responsibilities have included preliminary field investigations (Phase II) conducted for the New York State Department of Environmental Conservation at ten inactive hazardous waste disposal sites, and a remedial investigation and feasibility study conducted for the New York State Department of Environmental Conservation on a contaminated public water supply well.

APPENDIX B

LIST OF INTERVIEWEES AND OUTSIDE AGENCIES CONTACTED

TABLE B.1

LIST OF INTERVIEWEES

	Position	Years of Service at this Installation
1.	NCOIC, Corrosion Control	1
2.	NCOIC, Battery Shop	3
3.	Technician, PREL Shop	6
4.	NCOIC, Periodic Maintenance Shop	1
5.	NCOIC, Pneudraulics	12
6.	ANCOIC, Vehicle Entry Control Branch	1
7.	Technician, VECB, Vehicle Section	12
8.	NCOIC, Vehicle Entry Control Branch	3
9.	NCO, Shops Maintenance Branch, Quality Control	4
10.	Chief, Precision Measurement Electronics Lab	4
11.	Civilian, Refrigeration/AC Mechanic	31
12.	Civilian, Heating Shop Mechanic	29
13.	NCOIC, Heating Shop	5
14.	Civilian, Paint Shop Supervisor	29
15.	Civilian, Entomology Deputy Supervisor	20
16.	Civilian, Entomology Supervisor	19
17.	Civilian, Supply and Maintenance Supervisor	12
18.	NCOIC, Power Production	10
19.	Civilian, Power Production Mechanic	22
20.	Civilian, Allied Trades Supervisor	9
21.	NCO, General Purpose, Quality Control	5
22.	Civilian, General Purpose Mechanic	10
23.	Civilian, Special Purpose Supervisor	21
24.	NCOIC, Reproduction	4
25.	NCOIC, Base Photo Lab	3
26.	Civilian, Auto Hobby Shop Manager	10
27.	NCO, AGE Branch, Quality Control	6
28.	NCOIC, Jet Engine Shop	7
29.	NCOIC, 37ARRS, Corrosion Control	6
30.	NCOIC, 37ARRS, Operational Maintenance Branch	7

TABLE B.1

LIST OF INTERVIEWEES
(CONTINUED)

	Position	Years of Service at this Installation
31.	NCO, 37ARRS, Quality Assurance Inspector	7
32.	NCOIC, Medical Lab	4
33.	Civilian, X-ray Technician	4
34.	Civilian, Dental Lab Technician	3
35.	Civilian, Assistant Hospital Plant Manager	5
36.	Civilian, BX Service Station Manager	10
37.	NCO, Rivet Mile, Quality Control Inspector	5
38.	NCO, OMMS Building Maintenance	4
39.	Civilian, DPDO Supervisor	11
40.	Civilian, Procurement, Deputy Contracting Officer	29
41.	OIC, Bioenvironmental Engineer	1
42.	CES, Planning Officer	3
43.	CES, Draftsman	36
44.	Civilian, Consultant Board of Public Utilities	NA
45.	Assistant NCOIC, Conventional Munitions	6
46.	Civilian, Archeologist	NA
47.	NCO, Missile Maintenance	17
48.	Assistant NCOIC, Fuels Maintenance Branch	4
49.	Civilian, DPDO Chief	20
50.	Architech, Civil Engineering	3
51.	Civilian, Fire Department Chief	9
52.	Civilian, Heating Plant Foreman	17
53.	NCO, Missile Facilities Specialist	6
54.	Civilian, Construction Equipment Operator	37
55.	Civilian, Deputy Fire Chief, Retired	4
56.	Civilian, Pest Control Foreman	19
57.	Civilian, Deputy Chief Operations	21
58.	Civilian, Pavement and Grounds Superintendent	6
59.	Civilian, Ground Safety Manager	12

TABLE B.1

LIST OF INTERVIEWEES
(CONTINUED)

	Position	Years of Service at this Installation
60.	Civilian, Equipment Supervisor	21
61.	Weapons Safety Officer	3
62.	NCO, Weapons Safety Officer	14
63.	Civilian, Weapons Safety Officer	19
64.	NCO, Quality Control Inspector	3
65.	NCOIC, Base Historian	6
66.	OIC, Environmental Coordinator	2
67.	Civilian, Chief of Design	15

TABLE B.2
OUTSIDE AGENCY CONTACTS

- Mr. Marvin Crist, Hydrologist
  Mr. Len Cunningham, Hydrologist
  U.S. GEOLOGICAL SURVEY - WATER RESOURCES DIVISION
  Post Office Box 1125
  Cheyenne, Wyoming 82001
  307/772-2721

- Mr. Abe Stevenson, Soil Scientist
  U.S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE
  2120 Capitol Avenue, Room 8010
  Cheyenne, Wyoming 82001
  307/772-2316

- Mr. Bernard J. Dailey, Air Quality Engineer
  WYOMING DEPARTMENT OF ENVIRONMENTAL QUALITY
  Division of Air Quality
  122 West 25th Street
  Cheyenne, Wyoming 82002
  307/777-7391

- Mr. Lon Revall, Analyst
  WYOMING DEPARTMENT OF ENVIRONMENTAL QUALITY
  Solid Waste Management Program
  Herschler Building - 122 West 25th Street
  Cheyenne, Wyoming 82002
  307/777-7752

- Ms. Kate Louden
  Mr. John Wagner
  Mr. Leroy C. Feusner, SE District Supervisor
  Mr. Anthony J. Mancini, Groundwater Control Supervisor
  WYOMING DEPARTMENT OF ENVIRONMENTAL QUALITY
  Water Quality Division - Herschler Building - 122 West 25th Street
  Cheyenne, Wyoming 82002
  307/777-7781

- Mr. Thomas Crump, Groundwater Hydrologist
  WYOMING STATE ENGINEER'S OFFICE
  Herschler Building, 4E
  122 West 25th Street
  Cheyenne, Wyoming 82002
  307/777-7354

- Mr. Michael Stone
  Mr. Walt Gasson
  WYOMING DEPARTMENT OF FISH AND GAME
  Herschler Building - 122 West 25th Street
  Cheyenne, Wyoming 82002
  307/777-7781

TABLE B.2 (continued)
OUTSIDE AGENCY CONTACTS

- Mr. W. Lewis
  Modern Military Field Branch
  WASHINGTON NATIONAL RECORD CENTER
  4025 Suitland Road
  Suitland, Maryland
  (301) 763-1710

- Mr. J. Dwyer
  Cartographic and Architectural Branch
  NATIONAL ARCHIVES
  841 S. Pickett Street
  Alexandria, Virginia 22304
  (703) 756-6700

- Mr. E. Reese
  Modern Military Branch
  NATIONAL ARCHIVES
  8th and Pennsylvania Avenue
  Washington, DC
  (202) 523-3340

- Sgt. Jernigan
  Office of Air Force History
  BOLLING AFB
  Washington, DC
  (202) 767-5090

APPENDIX C

TENANT MISSIONS

APPENDIX C

TENANT MISSIONS - F.E. WARREN AFB

4TH AIR DIVISION

The mission of the 4th Air Division is to assure assigned units are capable of executing their mission of long range bombardment, sustained and effective air refueling, missile warfare, and strategic reconnaissance according to the emergency war orders.

37TH AEROSPACE RESCUE AND RECOVERY SQUADRON

The mission of the 37th Aerospace Rescue and Recovery Squadron is to assure assigned detachments are capable of executing their missions of providing support to the host units of the bases where 37 ARRS is deployed.

DETACHMENT 10, 37TH AEROSPACE RESCUE AND RECOVERY SQUADRON

The primary mission of Detachment 10 is to provide support for the 90th Strategic Missile Wing of F.E. Warren AFB. This support varies from routine daily missile crew changes to providing security surveillance for movement of Class A resources, emergency parts delivery, distinguished visitor transportation, and emergency disaster response operations.

GEODETIC SURVEY SQUADRON

The mission of the Geodetic Survey Squadron is to provide data for missile guidance and conduct precise surveys for special projects as assigned by the Department of Defense.

DETACHMENT 1402, OFFICE OF SPECIAL INVESTIGATIONS

The mission of Detachment 1402, Office of Special Investigations is to gather information affecting military security, criminal activity and counter intelligence matters.

DEFENSE INVESTIGATIVE SERVICE

The mission of the Defense Investigative Service is to perform security clearance investigations for all branches of the service. This is a field office for the Wyoming area.

OPERATING LOCATION A, 9TH WEATHER SQUADRON

The mission of Operating Location A, 9th Weather Squadron (MAC) is to provide up-to-date weather information tc base units throughout the three-state missile complex.

PEACEKEEPER SITE ACTIVATION TASK FORCE

The mission of the Peacekeeper Site Activation Task Force (SATAF) is to provide for construction, assembly, and checkout of the Peacekeeper missile system F.E. Warren AFB.

OPERATING LOCATION FA, DETACHMENT 15, 3904TH MANAGEMENT ENGINEERING SQUADRON

The mission of Operating Location FA, Detachment 15, 3904th Management Engineering Squadron is to provide management consultant service for commanders and functional managers at F.E. Warren AFB.

OGDEN AIR LOGISTICS CENTER

The mission of this on-base section of the Ogden Air Logistics Center is to modify the LF and LCF to meet the requirements of hardening that will allow them to remain an active part of the nation's deterrent force in the upcoming decade.

APPENDIX D

SUPPLEMENTAL BASE FINDINGS INFORMATION

TABLE D.1
F. E. WARREN AFB SURFACE WATER SAMPLING SUMMARY

Sampling Point: No. 1 - North Branch, Crow Creek (upstream)

Parameter		1981	1982	1983	Wyoming Water Quality Standard*
Temp (°C)			19	20	NS
pH		--	8.3	8.0	9
COD,	mg/l	12	10	25	NS
Oil/Grease,	mg/l	<0.3	<0.3	<0.3	10
D.O.,	mg/l	NSC	NSC	9	5
Ammonia,	mg/l	<0.2	<0.1	<0.45	NS
Nitrate,	mg/l	.3	<0.1	<0.1	NS
Nitrite,	mg/l	NSC	0.02	0.02	NS
Phosphorus,	mg/l	<0.01	<0.01	<0.01	NS
Cyanide,	mg/l	<0.01	<0.01	<0.01	NS
Phenols,	ug/l	<10	<10	<10	NS
Cadmium,	ug/l	<10	<10	<10	NS
Chromium,	ug/l	<50	<50	<50	NS
Copper,	ug/l	23	<50	<20	NS
Lead,	ug/l	<50	<20	<20	NS
Manganese,	ug/l	NSC	NSC	184	NS
Zinc,	ug/l	NSC	NSC	<50	NS
TDS,	mg/l	300	1200	421	NS
Iron,	ug/l	NSC	180	447	NS
Turbidity,	NTU	NSC	NSC	22	15

* = This is the standard applied to F. E. Warren AFB.
NS = No Standard (standard may exist but not applied to Warren)
NSC = No Sample Collected

SOURCE: USAF, 1983

TABLE D.1
(Continued)
F. E. WARREN AFB SURFACE WATER SAMPLING SUMMARY

Sampling Point: No. 2 - Crow Creek W. Branch Entrance

Parameter		1981	1982	1983	Wyoming Water Quality Standard*
Temp (°C)			21	23.5	NS
pH		--	7.1	8.2	9
COD,	mg/l	38	90	30	NS
Oil/Grease,	mg/l	10.4	NSC	<0.3	10
D.O.,	mg/l	NSC	NSC	7	5
Ammonia,	mg/l	0.2	0.5	<0.2	NS
Nitrate,	mg/l	.2	0.5	<0.1	NS
Nitrite,	mg/l	NSC	NSC	<0.02	NS
Phosphorus,	mg/l	<10	0.4	0.11	NS
Cyanide,	mg/l	<0.01	<0.01	<0.01	NS
Phenols,	ug/l	<10	20	<10	NS
Cadmium,	ug/l	<10	<10	<10	NS
Chromium,	ug/l	<50	<50	<50	NS
Copper,	ug/l	<20	<50	<20	NS
Lead,	ug/l	<50	<20	<20	NS
Manganese,	ug/l	NSC	NSC	73	NS
Zinc,	ug/l	NSC	NSC	650	NS
TDS,	mg/l	588	580	351	NS
Iron,	ug/l	NSC	NSC	176	NS
Turbidity,	NTU	NSC	NSC	2	15

* = This is the standard applied to F. E. Warren AFB.
NS = No Standard (standard may exist but not applied to Warren)
NSC = No Sample Collected

SOURCE: USAF, 1983

TABLE D.1
(Continued)
F. E. WARREN AFB SURFACE WATER SAMPLING SUMMARY

Sampling Point: No. 3 - Crow Creek, W. Branch End

Parameter		1981	1982	1983	Wyoming Water Quality Standard*
Temp (°C)			18	24	NS
pH		--	7.7	8.2	9
COD,	mg/l	10	20	15	NS
Oil/Grease,	mg/l	<0.3	NSC	<0.3	10
D.O.,	mg/l	NSC	NSC	NSC	5
Ammonia,	mg/l	<0.2	<0.2	<0.2	NS
Nitrate,	mg/l	<0.1	<0.1	0.1	NS
Nitrite,	mg/l	NSC	NSC	<0.02	NS
Phosphorus,	mg/l	<0.1	<0.1	0.12	NS
Cyanide,	mg/l	<0.01	<0.01	<0.01	NS
Phenols,	ug/l	<10	<10	<10	NS
Cadmium,	ug/l	<10	<10	<10	NS
Chromium,	ug/l	<50	<50	<50	NS
Copper,	ug/l	NSC	<50	<20	NS
Lead,	ug/l	<50	<20	25	NS
Manganese,	ug/l	NSC	NSC	212	NS
Zinc,	ug/l	NSC	NSC	<50	NS
TDS,	mg/l	311	300	369	NS
Iron,	ug/l	NSC	NSC	546	NS
Turbidity,	NTU	NSC	NSC	30	15

* = This is the standard applied to F. E. Warren AFB.
NS = No Standard (standard may exist but not applied to Warren)
NSC = No Sample Collected

SOURCE: USAF, 1983

TABLE D.1
(Continued)
F. E. WARREN AFB SURFACE WATER SAMPLING SUMMARY

Sampling Point: No. 4 - Crow Creek, North Branch End

Parameter		1981	1982	1983	Wyoming Water Quality Standard*
Temp (°C)		--	20	21	NS
pH		--	7.7	8.2	9
COD,	mg/l	17	20	28	NS
Oil/Grease,	mg/l	<0.3	NSC	<0.3	10
D.O.,	mg/l	NSC	NSC	NSC	5
Ammonia,	mg/l	<0.2	<0.1	<0.2	NS
Nitrate,	mg/l	<0.1	<0.1	<0.1	NS
Nitrite,	mg/l	NSC	NSC	0.02	NS
Phosphorus,	mg/l	<0.1	<0.1	<0.1	NS
Cyanide,	mg/l	<0.01	<0.01	<0.01	NS
Phenols,	ug/l	<10	<10	<10	NS
Cadmium,	ug/l	NSC	<10	<10	NS
Chromium,	ug/l	NSC	<50	<50	NS
Copper,	ug/l	NSC	<50	<20	NS
Lead,	ug/l	<50	<20	<20	NS
Manganese,	ug/l	NSC	NSC	63	NS
Zinc,	ug/l	NSC	NSC	<50	NS
TDS,	mg/l	281	300	365	NS
Iron,	ug/l	NSC	NSC	236	NS
Turbidity,	NTU	NSC	NSC	2	15

* = This is the standard applied to F. E. Warren AFB.
NS = No Standard (standard may exist but not applied to Warren)
NSC = No Sample Collected

SOURCE: USAF, 1983

TABLE D.1
(Continued)
F. E. WARREN AFB SURFACE WATER SAMPLING SUMMARY

Sampling Point: No. 5 - Crow Creek, Mid-Point

Parameter		1981	1982	1983	Wyoming Water Quality Standard*
Temp (°C)		--	--	22.5	NS
pH		--	--	8.2	9
COD,	mg/l	<10	<10	20	NS
Oil/Grease,	mg/l	<0.3	NSC	<0.3	10
D.O.,	mg/l	NSC	NSC	NSC	5
Ammonia,	mg/l	<0.2	<0.2	<0.2	NS
Nitrate,	mg/l	0.1	<0.1	0.8	NS
Nitrite,	mg/l	NSC	NSC	<0.02	NS
Phosphorus,	mg/l	<0.1	<0.1	0.1	NS
Cyanide,	mg/l	<0.01	<0.01	<0.01	NS
Phenols,	ug/l	<10	<10	<10	NS
Cadmium,	ug/l	<10	<10	<10	NS
Chromium,	ug/l	<50	<50	<50	NS
Copper,	ug/l	<50	<50	<20	NS
Lead,	ug/l	<50	<20	<20	NS
Manganese,	ug/l	NSC	NSC	164	NS
Zinc,	ug/l	NSC	NSC	<50	NS
TDS,	mg/l	169	270	351	NS
Iron,	ug/l	NSC	NSC	475	NS
Turbidity,	NTU	NSC	NSC	25	15

* = This is the standard applied to F. E. Warren AFB.
NS = No Standard (standard may exist but not applied to Warren)
NSC = No Sample Collected

SOURCE: USAF, 1983

TABLE D.1
(Continued)
F. E. WARREN AFB SURFACE WATER SAMPLING SUMMARY

Sampling Point: No. 6 - Crow Creek before South Branch

Parameter		1981	1982	1983	Wyoming Water Quality Standard*
Temp (°C)		--	19	23	NS
pH		--	7.5	8.0	9
COD,	mg/l	11	<10	20	NS
Oil/Grease,	mg/l	<0.3	NSC	<0.3	10
D.O.,	mg/l	NSC	NSC	NSC	5
Ammonia,	mg/l	<0.2	0.1	<0.2	NS
Nitrate,	mg/l	2.4	0.4	0.11	NS
Nitrite,	mg/l	NSC	NSC	<0.02	NS
Phosphorus,	mg/l	<0.1	<0.1	6.25	NS
Cyanide,	mg/l	<0.01	<0.01	<0.01	NS
Phenols,	ug/l	<10	<10	<10	NS
Cadmium,	ug/l	<10	<10	<10	NS
Chromium,	ug/l	<50	<50	<50	NS
Copper,	ug/l	<50	<20	<50	NS
Lead,	ug/l	<50	<20	<20	NS
Manganese,	ug/l	NSC	NSC	151	NS
Zinc,	ug/l	NSC	NSC	<50	NS
TDS,	mg/l	337	310	395	NS
Iron,	ug/l	NSC	170	441	NS
Turbidity,	NTU	NSC	NSC	24	15

* = This is the standard applied to F. E. Warren AFB.
NS = No Standard (standard may exist but not applied to Warren)
NSC = No Sample Collected

SOURCE: USAF, 1983

TABLE D.1
(Continued)

F. E. WARREN AFB SURFACE WATER SAMPLING SUMMARY

Sampling Point: No. 7 - Crow Creek, South End

Parameter		1981	1982	1983	Wyoming Water Quality Standard*
Temp (°C)		--	11	17.8	NS
pH		--	7.5	7.8	9
COD,	mg/l	<10	<10	25	NS
Oil/Grease,	mg/l	NSC	NSC	<0.3	10
D.O.,	mg/l	NSC	NSC	NSC	5
Ammonia,	mg/l	<0.2	0.1	<0.2	NS
Nitrate,	mg/l	0.2	0.2	0.11	NS
Nitrite,	mg/l	NSC	NSC	<0.02	NS
Phosphorus,	mg/l	<0.1	<0.1	13	NS
Cyanide,	mg/l	<0.01	<0.01	<0.01	NS
Phenols,	ug/l	NSC	<10	<10	NS
Cadmium,	ug/l	<10	<10	<10	NS
Chromium,	ug/l	<50	<50	<50	NS
Copper,	ug/l	<20	<50	<20	NS
Lead,	ug/l	<50	<20	<20	NS
Manganese,	ug/l	NSC	NSC	227	NS
Zinc,	ug/l	NSC	NSC	<50	NS
TDS,	mg/l	402	480	861	NS
Iron,	ug/l	NSC	680	1412	NS
Turbidity,	NTU	NSC	NSC	2	15

* = This is the standard applied to F. E. Warren AFB.
NS = No Standard (standard may exist but not applied to Warren)
NSC = No Sample Collected

SOURCE: USAF, 1983

TABLE D.1
(continued)

F. E. WARREN AFB SURFACE WATER SAMPLING SUMMARY

Sampling Point: No. 8 - Crow Creek, SE Exit Base

Parameter		1981	1982	1983	Wyoming Water Quality Standard*
Temp (°C)		--	19	25	NS
pH		--	7.7	8.2	9
COD,	mg/l	<10	<10	<10	NS
Oil/Grease,	mg/l	NSC	NSC	.3	10
D.O.,	mg/l	NSC	NSC	NSC	10
Ammonia,	mg/l	<0.2	<0.2	<0.2	NS
Nitrate,	mg/l	0.3	0.6	0.6	NS
Nitrite,	mg/l	NSC	NSC	<0.02	NS
Phosphorus,	mg/l	<0.1	0.1	0.16	NS
Cyanide,	mg/l	<0.01	<0.01	<0.01	NS
Phenols,	ug/l	NSC	20	<10	NS
Cadmium,	ug/l	<10	<10	<10	NS
Chromium,	ug/l	<50	<50	<50	NS
Copper,	ug/l	34	<50	<20	NS
Lead,	ug/l	<50	<20	<20	NS
Manganese,	ug/l	NSC	NSC	140	NS
Zinc,	ug/l	NSC	NSC	<50	NS
TDS,	mg/l	307	350	344	NS
Iron,	ug/l	NSC	500	424	NS
Turbidity,	NTU	NSC	NSC	24	15

* = This is the standard applied to F. E. Warren AFB.
NS = No Standard (standard may exist but not applied to Warren)
NSC = No Sample Collected

SOURCE: USAF, 1983

TABLE D.2

STATE OF WYOMING GROUNDWATER QUALITY STANDARDS

UNDERGROUND WATER CLASS Use Suitability Constituent or Parameter	I Domestic Concent.*	II Agriculture Concent.*	III Livestock Concent.*	Special (A) Fish/ Aquatic Life Concent.*
Aluminum (Al)	--	5.0	5.0	0.1
Ammonia (NH_3-N)	0.5[8]	--	--	0.02[1]
Arsenic (As)	0.05	0.1	0.2	0.05
Barium (Ba)	1.0	--	--	5.0
Beryllium (Be)	--	0.1	--	0.011-1.1[3]
Boron (B)	0.75	0.75	5.0	--
Cadmium (Cd)	0.01	0.01	0.05	0.0004-0.015[3]
Chloride (Cl)	250.0	100.0	2000.0	--
Chromium (Cr)	0.05	0.1	0.05	0.05
Cobalt (Co)	--	0.05	1.0	--
Copper (Cu)	1.0	0.2	0.5	0.01-0.04[3]
Cyanide (Cn)	0.2	--	--	0.005
Fluoride (F)	1.4-2.4[7]	--	--	--
Hydrogen Sulfide (H_2S)	0.05	--	--	0.002[2]
Iron (Fe)	0.3	5.0	--	0.5
Lead (Pb)	0.05	5.0	0.1	0.004-0.15[3]
Lithium (Li)	--	2.5	--	--
Manganese (Mn)	0.05	0.2	--	1.0
Mercury (Hg)	0.002	--	0.00005	0.00005
Nickel (Ni)	--	0.2	--	0.05-0.4[3]
Nitrate (No_3-N)	10.0	--	--	--
Nitrite (NO_2-N)	1.0	--	10.0	--
(NO_3+NO_2)-N	--	--	100.0	--
Oil & Grease	Virtually Free	10.0	10.0	Virtually Free
Phenol	0.001	--	--	0.001
Selenium (Se)	0.01	0.02	0.05	0.05
Silver (Ag)	0.05	--	--	0.0001-0.00025[3]
Sulfate (SO_4)	250.0	200.0	3000.0	--
Total Dissolved Solids (TDS)	500.0	2000.0	5000.0	500.0[4]-1000.0[5]-2000.0[6]
Uranium (U)	5.0	5.0	5.0	0.03-1.4[3]
Vanadium (V)	--	0.1	0.1	--
Zinc (Zn)	5.0	2.0	25.0	0.05-0.6[3]
pH	6.5-9.0 s.u.	4.5-9.0 s.u.	6.5-8.5 s.u.	6.5 s.u.-9.0s.u.
SAR	--	8	--	
RSC	--	1.25 meq/l	--	
Combined Total Radium 226 and Radium 228[9]	5pCi/l	5pCi/l	5pCi/l	5pCi/l
Total Strontium 90	8pCi/l	8pCi/l	8pCi/l	8pCi/l
Gross alpha particle radioactivity (including Radium 226 but excluding Radon and Uranium)[9]	15pCi/l	15pCi/l	15pCi/l	15pCi/l

*mg/l, unless otherwise indicated

TABLE D.2
(continued)

EXPLANATION FOR SUPERSCRIPT USED IN TABLE D.2

[1] Unionized ammonia: When ammonia dissolves in water, some of the ammonia reacts with water to form ammonium ions. A chemical equilibrium is established which contains unionized ammonia (NH_3), ionized ammonia (NH_4+) and hydroxide ions (OH^-). The toxicity of aqueous solutions of ammonia is attributed to NH_3); therefore, the standard is for unionized ammonia. (Note: 0.02 mg/l NH_3 is equivalent to 0.016 NH_3 as N.)

[2] Undissociated H_2S: The toxicity of sulfides derives primarily from H_2S, rather than from the dissociated (HS) or (S) ions; therefore, the standard is for the toxic undissociated H_2S.

[3] Dependent on hardness: The toxicity of metals is natural waters varies with the hardness of the water; generally, the limiting concentration is greater in hard water than in soft water.

[4] Egg hatching
[5] Fish rearing
[6] Fish and aquatic life

[7] Dependent on the annual average of the maximum daily air temperature: 1.4 mg/l corresponds with a temperature range of 26.3 to 32.5 degrees C and 2.4 mg/l corresponds with a temperature of 12.0 degrees C (53.7 degrees F) and below.

[8] Total ammonia-nitrogen

[9] Requirements and procedures for the measurement and analysis of gross alpha particle activity, Radium 226 and Radium 228 shall be the same as requirements and procedures of the U.S. Environmental Protection Agency, National Interim Primary Drinking Water Regulations, EPA-570/9-76-003, effective 24 June 1977.

SOURCE: Water Quality Standards for Wyoming Groundwater, 1980. Wyoming Department of Environmental Quality, Water Quality Division.

TABLE D.3

LIST OF OIL/WATER SEPARATORS

F. E. WARREN AFB

Facility No.	Facility Description
321	CE, Pavements and Grounds
324	Base Fire Station
332	Vehicle Entry Control Branch
356	Auto Hobby Shop
400	Base Service Station
810	Transportation, Special Purpose
826	Transportation, General Purpose
828	Transportation, Wash Rack
1250	Aerospace Rescue and Recovery Squadron
305	Undesignated

Source: Base Documents

TABLE D.4

PESTICIDE INVENTORY AS OF NOVEMBER, 1984

F. E. WARREN AFB

Trade Name	Concentration (%)
Techmar	8
Dursban 10 CR	10.6
Malathion	55
Malathion ULV-91	91
Dursban	41
Ficam Plus	29.5, 3.1
Knox-out 2FM	23
Killmaster II	2
Raze	0.025
Peters Rodent Killer	0.37
Phostoxin	55
Giant Destroyer	46, 34, 8
Rozol Tracking Powder	27
Dursban 4E	41.2
Sevimol - 4	40.4
Ficam W	76
Diazinon	48
Ficam W	76
Raid Wasp and Hornet Killer	0.48
Sevin 5 Bait	5

Source: Base Documents

TABLE D.5
PETROLEUM STORAGE FACILITIES
F. E. WARREN AFB

Facility No.	Tank Capacity (Gal)	Product	Description
160	24,000	Diesel	A
310	2,500	Diesel	A
355	4,500	JP-4	A
355	1,200	Mogas	A
355	2,400	Diesel	A
400	3 X 10,000	Mogas	A
830	10,000	Diesel	U
830	4 X 10,000	Mogas	A
830	2 X 1,000	Propane	A
6403	14 X 24,000	Propane	A
All LFs	14,500	Diesel	U
All LCFs	14,000	Diesel	U
All LCFs	2,500	Diesel	U
All LCFs	1,000	Diesel	U
All LCFs	1,000	Mogas (Unleaded)	U
12 LCFs	2,000	Mogas	A
8 LCFs	1,000	Mogas	A
2141	1,000	Diesel	A
34	500	Diesel	U
65	500	Diesel	U
321 (F50)	500	Mogas	A
321 (F54)	500	Diesel	A
650	2 X 500	Diesel	U
1150	500 (Abandoned)	Diesel	U
1250	500	Diesel	U
1255	500	Mogas	A
2138	500	Mogas	A
336	200	Waste Oil	A
810	300	Waste Oil	A
400	500	Waste Oil	U
356	500	Waste Oil	U

Source - F. E. Warren AFB Spill Prevention and Response Plan, February 1, 1984

Note: A - Aboveground
U - Underground

TABLE D.6
WATER QUALITY RESULTS FROM MONITORING WELLS AT TCE SPILL SITE
(Results parts per billion)

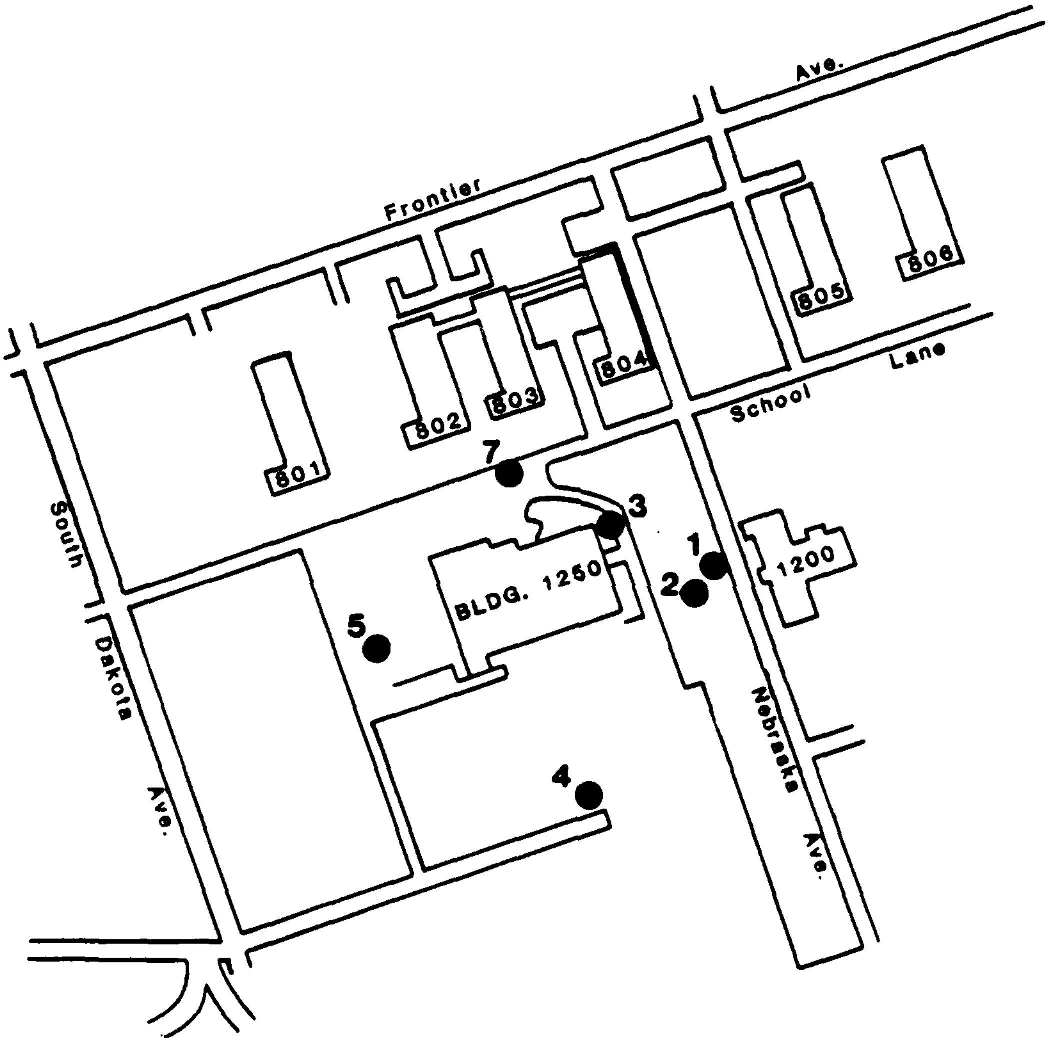
Parameters	06/12/84 Well #			08/07/84 Well #			02/21/85 Well #						07/31/85 Well #					
	1	2	3	1	2	3	1	2	3	4	5	7	1	2	3	4	5	7
Bromodichloromethane	0.3	0.3	0.9	0.6	0.3	1.7	0.7	0.4	1.7	0.4	1.8	2.4	ND	ND	ND	ND	ND	ND
Bromoform							ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Bromomethane							ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Carbon Tetrachloride							ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chlorobenzene							ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chloroethane							ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2-chloroethylvinyl ether							ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chloroform	13	18	12	14.7	23	13.9	17.1	22.7	20.7	3.4	19.1	20.5	23	26.1	19.5	11.8	26.3	16.9
	14.4*	20.4*	15.6*															
Chloromethane							ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dibromochloromethane							ND	ND	ND	ND	0.4	1.4	ND	ND	ND	ND	ND	ND
1,2-Dichlorobenzene							ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,3-Dichlorobenzene							ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,4-Dichlorobenzene							ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dichlorodifluoromethane							ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1-Dichloroethane							ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2-Dichloroethane							ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1-Dichloroethene							ND	ND	ND	ND	ND	9.1	ND	ND	ND	ND	ND	ND
trans-1,2-Dichloroethene							2.2	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2-Dichloropropane							ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
cis-1,3-Dichloropropene							ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
trans-1,3-Dichloropropene							ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Methylene Chloride	0.4	ND	ND	ND	0.5	0.5	ND	ND	ND	ND	0.6	ND	ND	ND	ND	ND	ND	ND
1,1,2,2-Tetrachloroethane							ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Tetrachloroethylene	0.7	ND	0.2				0.9	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,1-Trichloroethane	ND	ND	0.3	Tr	0.3	0.3	Tr	Tr	Tr	ND	Tr	10.6	ND	ND	ND	ND	ND	34.8
1,1,2-Trichloroethane							ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Trichloroethylene	7.5	1.2	33	25.3	0.9	35	20.4	0.7	45.7	ND	0.4	2.6	27	1.3	57.1	1.4	1.7	7.8
	18.3*	ND*	65.7*															
Trichlorofluoromethane							ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Vinyl Chloride							ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

ND = Non Detected, less than the detection limit.
Tr = Trace
* Duplicate sample results obtained by State of Wyoming.
Source: F. E. Warren AFB (1984/1985)

FIGURE D.1

F.E. WARREN AFB

MONITORING WELLS AT SPILL SITE NO. 4



NOTE:

WELLS 1,2,3 INSTALLED 1984

WELLS 4,5,7 INSTALLED 1985

SCALE 0 400 FEET

SOURCE: INSTALLATION DOCUMENTS

APPENDIX E

MASTER LIST OF INDUSTRIAL SHOPS

APPENDIX E
MASTER LIST OF INDUSTRIAL SHOPS
F. E. WARREN AFB

Name	Present Location (Bldg. No.)	Handles Hazardous Materials	Generates Hazardous Wastes	Waste Management Practices
90th Field Missile Maintenance Squadron				
Battery Shop	338	Yes	Yes	DPDO, OBC
Corrosion Control	336	Yes	No	--
Precision Measurements Electronics Lab	341	Yes	Yes	OBC, DPDO
Periodic Maintenance Team	336	Yes	Yes	OBC
Pneudraulics	336	Yes	Yes	OBC
Vechile Entry Control Branch	332	Yes	No	--
Re-Entry Systems	1152	Yes	No	--
Power Refrigeration Electronic Lab	336	Yes	Yes	OBC
Mechanical Shop	336	Yes	No	--
90th Civil Engineering Squadron				
Pavements and Equipment	321	No	No	--
Plumbing Shop	381	Yes	No	--
Refrigeration	367	Yes	Yes	Sanitary Sewer
Power Production	316	Yes	Yes	OBC Discharge to Adjacent Lots

APPENDIX E
MASTER LIST OF INDUSTRIAL SHOPS
F. E. WARREN AFB

Name	Present Location (Bldg. No.)	Handles Hazardous Materials	Generates Hazardous Wastes	Waste Management Practices
90th Civil Engineering Squadron (Continued)				
Water/Waste	316	Yes	No	--
Entomology	316	Yes	Yes	DPDO, Reused for Make-up
Protective Coating	317	Yes	Yes	OBC Discharge on Adjacent Lots
Heating Plant	6501	Yes	Yes	OBC
Heating Shop	318	Yes	Yes	Landfill, Neutralized to Sanitary Sewer
Masonary	366	Yes	No	--
SMART	317	Yes	No	--
Grounds	321	Yes	No	--
Sheetmetal and Welding	318	Yes	No	--
Structural Repair (Carpentry)	317	Yes	No	--
Exterior Electric	320	Yes	Yes	OBC
Interior Electric	318	No	No	--

APPENDIX E
MASTER LIST OF INDUSTRIAL SHOPS
F. E. WARREN AFB

Name	Present Location (Bldg. No.)	Handles Hazardous Materials	Generates Hazardous Wastes	Waste Management Practices
90th Transportation Squadron				
Packing and Crating	386	Yes	No	--
General Purpose	826	Yes	Yes	OBC, Neutralized to Dry Well, DPDO, Sanitary Sewer
Allied Trades	810	Yes	Yes	OBC
Special Purpose	810	Yes	Yes	OBC
90th Combat Support Group				
Auto Hobby Shop	356	Yes	Yes	OBC
Wood Hobby Shop	356	Yes	No	--
Ceramics	356	No	No	--
Photo Laboratory	242	Yes	Yes	Silver Recovery to Sanitary Sewer
Small Arms Range	341	Yes	No	--
Reproduction	232	Yes	No	--
90th Organizational Missile Maintenance Squadron				
Missile Electric Branch	340	Yes	No	--
Missile Maintenance Branch	340	Yes	No	--

APPENDIX E
MASTER LIST OF INDUSTRIAL SHOPS
F. E. WARREN AFB

Name	Present Location (Bldg. No.)	Handles Hazardous Materials	Generates Hazardous Wastes	Waste Management Practices
Detachment 10, 37th Aerospace Rescue and Recovery Squadron				
Aerospace Ground Equip. (AGE)	1250	Yes	Yes	OBC
Pneudraulics	1250	Yes	Yes	OBC
Machine/Sheet Metal	1250	Yes	No	--
Corrosion Control	1250	Yes	Yes	OBC
Jet Engine Shop	1250	Yes	Yes	OBC
Operational Maintenance Branch	1250	Yes	Yes	Sanitary Sewer, OBC
USAF Hospital, F. E. Warren				
Dental Lab	160	Yes	Yes	Sanitary Sewer
Medical/Dental X-Ray	160	Yes	Yes	Silver Recovery to Sanitary Sewer
Medical Lab	160	Yes	Yes	Sanitary Sewer
Surgery	160	Yes	No	--
Incinerator	160	Yes	Yes	Landfill
2149th Informations Systems Squadron				
Cable Maintenance	1250	Yes	No	--
Base Cable	65	No	No	--

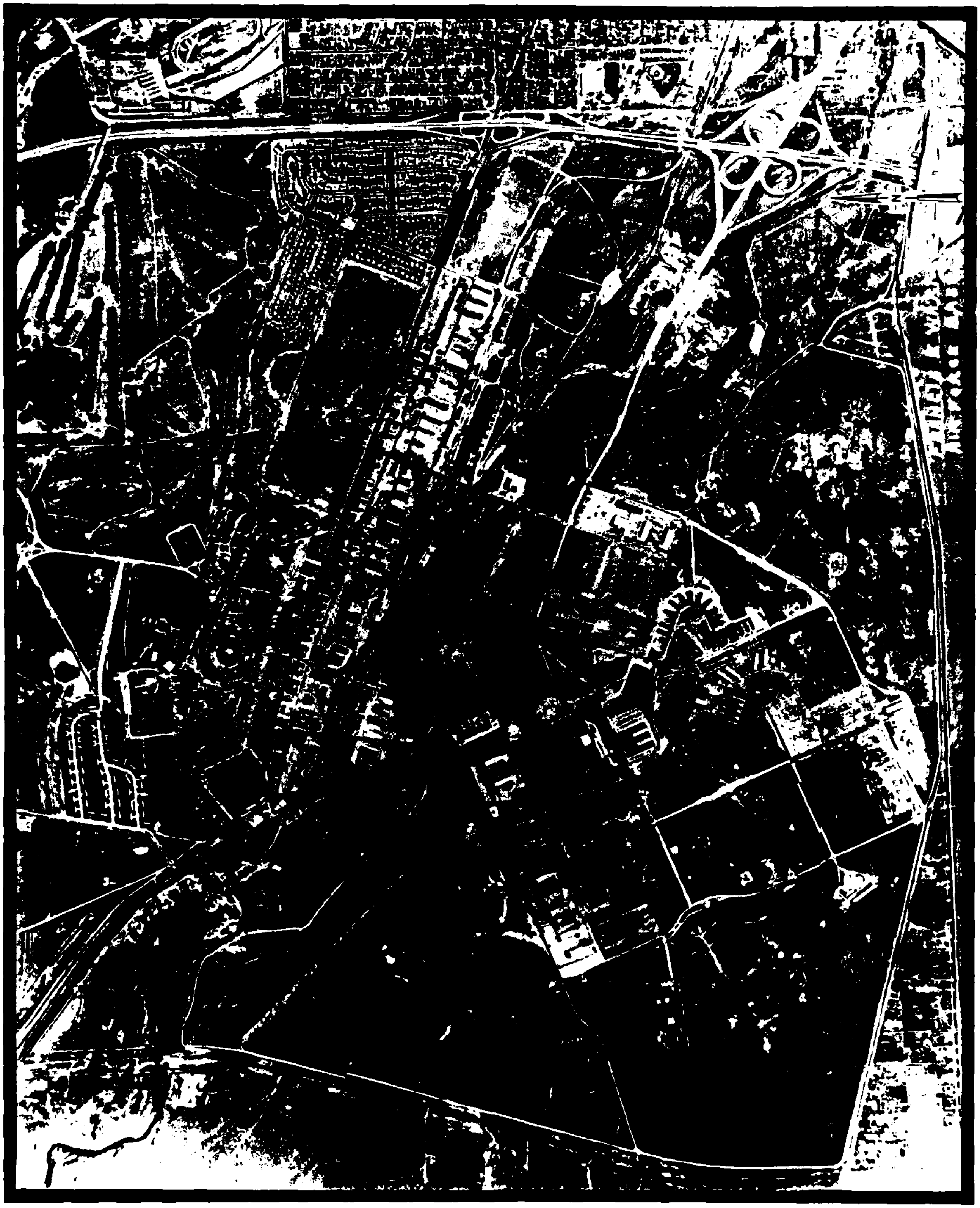
APPENDIX E
MASTER LIST OF INDUSTRIAL SHOPS
F. E. WARREN AFB

Name	Present Location (Bldg. No.)	Handles Hazardous Materials	Generates Hazardous Wastes	Waste Management Practices
Army and Air Force Exchange Services				
Service Station	400	Yes	Yes	OBC

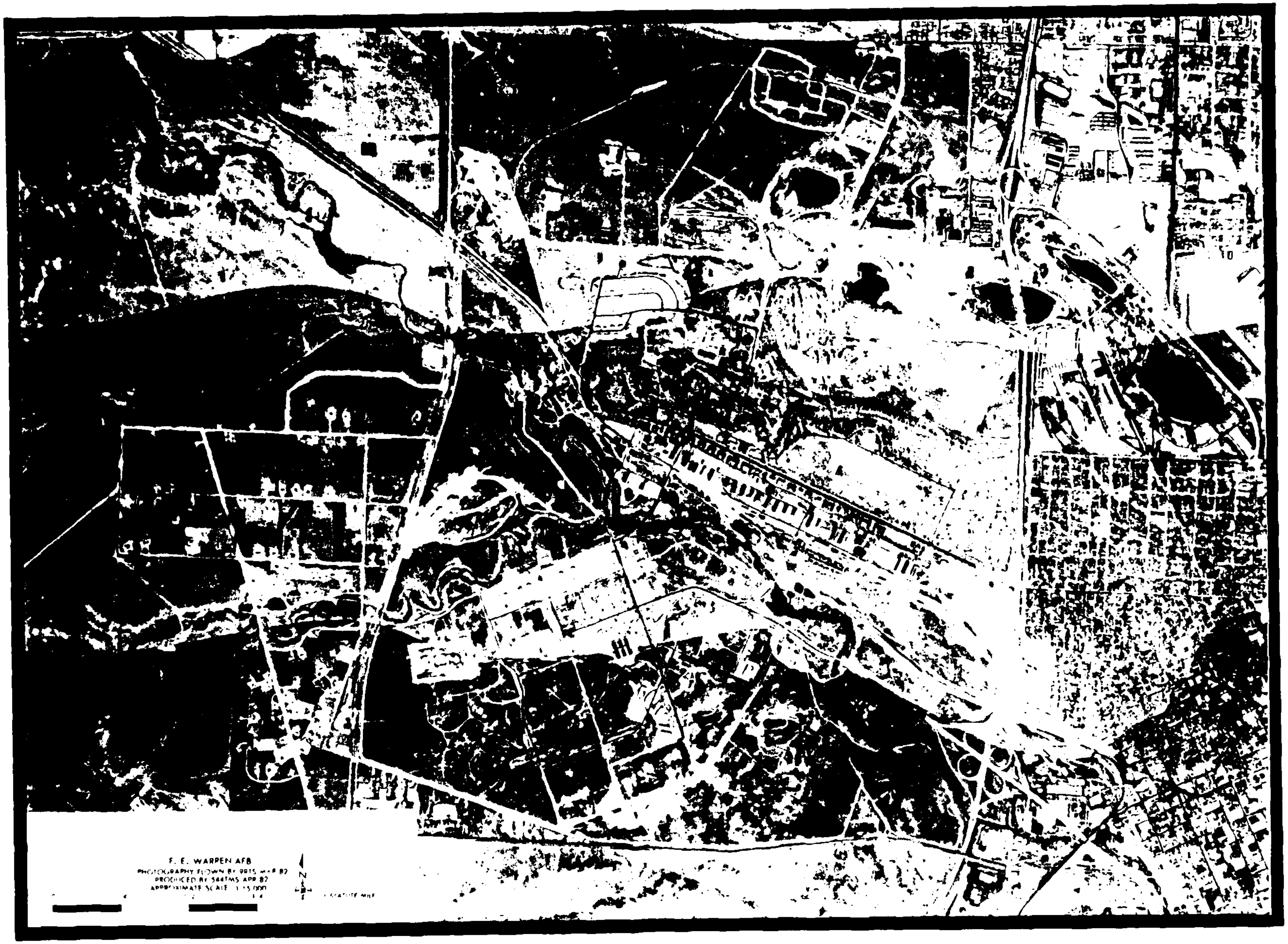
APPENDIX F

PHOTOGRAPHS

F.E. WARREN AFB, WYOMING CIRCA 1954



F.E. WARREN AFB, WYOMING CIRCA 1963



F.E. WARREN AFB, WYOMING **CIRCA 1982**

Spill Site No. 4
(bldg. 1250 TCE spill)

Landfill No. 4

Landfill No. 6

Landfill No. 2
(right of East Rd.)

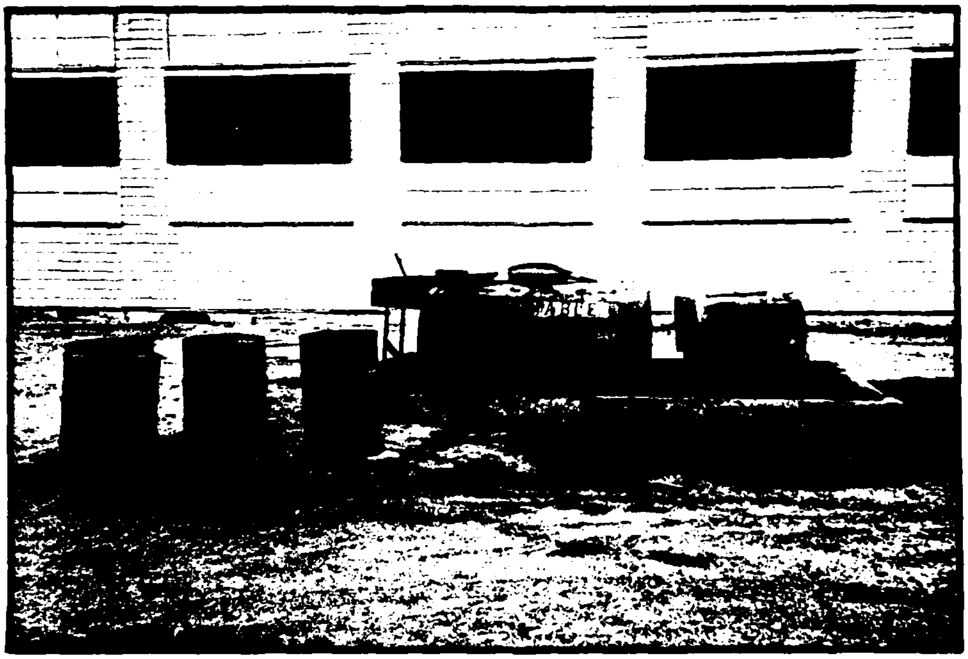
Landfill No. 5

Spill Site No. 1
(bldg. 400, service station)

FPTA No. 2

Spill Site No. 2
(bldg. 810)

F.E. WARREN AFB



Spill Site No. 2
(bldg. 810)

Acid Dry Well
(bldg. 826)

Landfill No. 3
(in foreground)

Spill Site No. 5
(bldg. 336)

Spill Site No. 6
(bldg. 316)

APPENDIX G

USAF INSTALLATION RESTORATION PROGRAM

HAZARD ASSESSMENT RATING METHODOLOGY

APPENDIX G

USAF INSTALLATION RESTORATION PROGRAM
HAZARD ASSESSMENT RATING METHODOLOGY

BACKGROUND

The Department of Defense (DOD) has established a comprehensive program to identify, evaluate, and control problems associated with past disposal practices at DOD facilities. One of the actions required under this program is to:

> "develop and maintain a priority listing of contaminated installations and facilities for remedial action based on potential hazard to public health, welfare, and environmental impacts." (Reference: DEQPPM 81-5, 11 December 1981).

Accordingly, the United States Air Force (USAF) has sought to establish a system to set priorities for taking further actions at sites based upon information gathered during the Records Search phase of its Installation Restoration Program (IRP).

The first site rating model was developed in June 1981 at a meeting with represenatives from USAF Occupational and Environmental Health Laboratory (OEHL), Air Force Engineering and Services Center (AFESC), Engineering-Science (ES) and CH2M Hill. The basis for this model was a system developed for EPA by JRB Associates of McLean, Virginia. The JRB model was modified to meet Air Force needs.

After using this model for 6 months at over 20 Air Force installations, certain inadequacies became apparent. Therefore, on January 26 and 27, 1982, representatives of USAF OEHL, AFESC, various major commands, Engineering-Science, and CH2M Hill met to address the inadequacies. The result of the meeting was a new site rating model designed to present a better picture of the hazards posed by sites at Air Force installations. The new rating model described in this presentation is referred to as the Hazard Assessment Rating Methodology.

PURPOSE

The purpose of the site rating model is to provide a relative ranking of sites of suspected contamination from hazardous substances. This model will assist the Air Force in setting priorities for follow-on site investigations and confirmation work under Phase II of the IRP.

This rating system is used only after it has been determined that (1) potential for contamination exists (hazardous wastes present in sufficient quantity), and (2) potential for migration exists. A site can be deleted from consideration for rating on either basis.

DESCRIPTION OF MODEL

Like the other hazardous waste site ranking models, the U.S. Air Force's site rating model uses a scoring system to rank sites for priority attention. However, in developing this model, the designers incorporated some special features to meet specific DOD program needs.

The model uses data readily obtained during the Records Search portion (Phase I) of the IRP. Scoring judgments and computations are easily made. In assessing the hazards at a given site, the model develops a score based on the most likely routes of contamination and the worst hazards at the site. Sites are given low scores only if there are clearly no hazards at the site. This approach meshes well with the policy for evaluating and setting restrictions on excess DOD properties.

As with the previous model, this model considers four aspects of the hazard posed by a specific site: the possible receptors of the contamination, the waste and its characteristics, potential pathways for waste contaminant migration, and any efforts to contain the contaminants. Each of these categories contains a number of rating factors that are used in the overall hazard rating.

The receptors category rating is calculated by scoring each factor, multiplying by a factor weighting constant and adding the weighted scores to obtain a total category score.

The pathways category rating is based on evidence of contaminant migration or an evaluation of the highest potential (worst case) for contaminant migration along one of three pathways. If evidence of contaminant migration exists, the category is given a subscore of 80 to 100 points. For indirect evidence, 80 points are assigned and for direct evidence, 100 points are assigned. If no evidence is found, the highest score among three possible routes is used. These routes are surface water migration, flooding, and ground-water migration. Evaluation of each route involves factors associated with the particular migration route. The three pathways are evaluated and the highest score among all four of the potential scores is used.

The waste characteristics category is scored in three steps. First, a point rating is assigned based on an assessment of the waste quantity and the hazard (worst case) associated with the site. The level of confidence in the information is also factored into the assessment. Next, the score is multiplied by a waste persistence factor, which acts to reduce the score if the waste is not very persistent. Finally, the score is further modified by the physical state of the waste. Liquid wastes receive the maximum score, while scores for sludges and solids are reduced.

The scores for each of the three categories are then added together and normalized to a maximum possible score of 100. Then the waste management practice category is scored. Sites at which there is no containment are not reduced in score. Scores for sites with limited containment can be reduced by 5 percent. If a site is contained and well managed, its score can be reduced by 90 percent. The final site score is calculated by applying the waste management practices category factor to the sum of the scores for the other three categories.

FIGURE 1

HAZARD ASSESSMENT RATING METHODOLOGY FLOW CHART

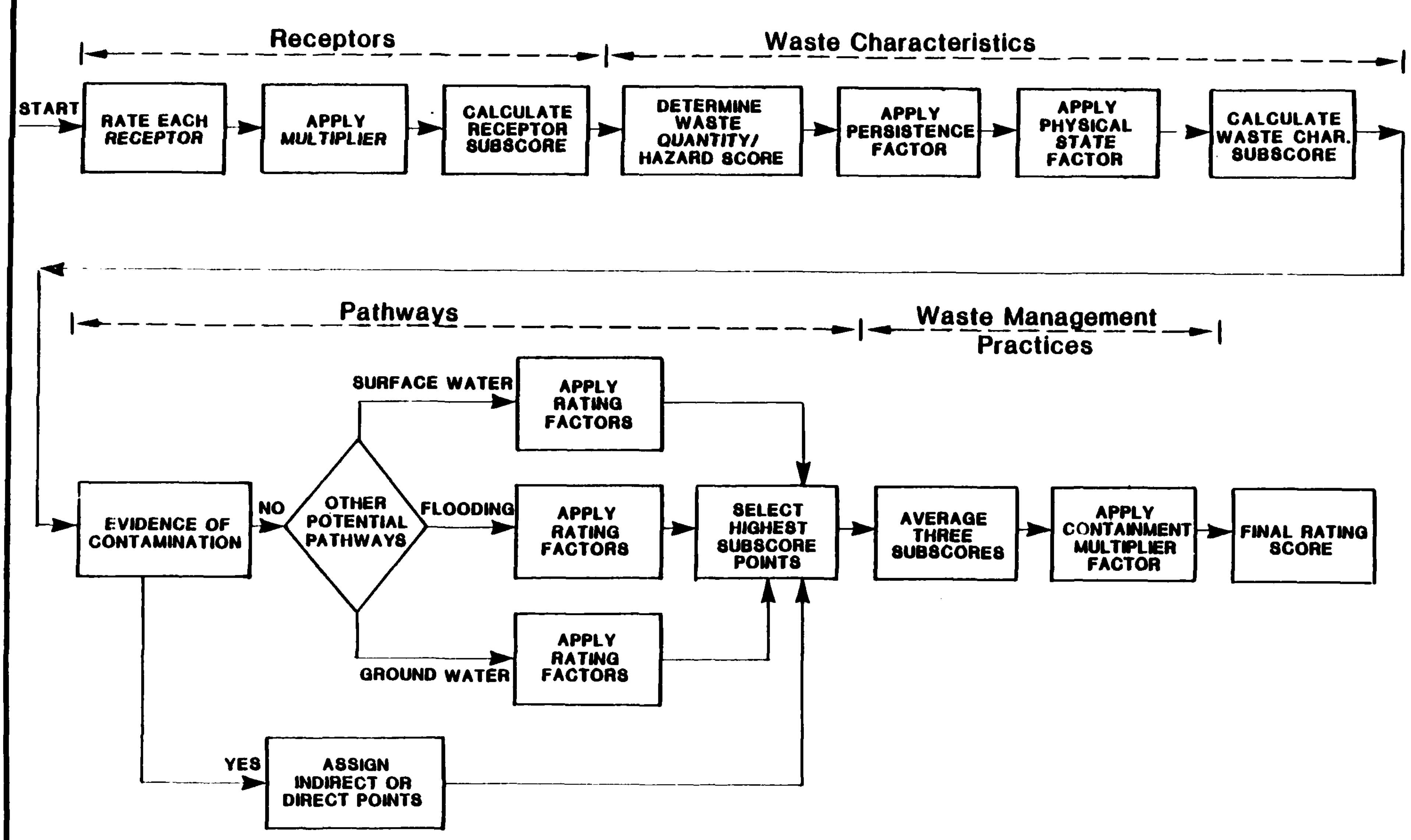


FIGURE 2

HAZARD ASSESSMENT RATING METHODOLOGY FORM

NAME OF SITE ______________________

LOCATION ______________________

DATE OF OPERATION OR OCCURRENCE ______________________

OWNER/OPERATOR ______________________

COMMENTS/DESCRIPTION ______________________

SITE RATED BY ______________________

I. RECEPTORS

Rating Factor	Factor Rating (0-3)	Multiplier	Factor Score	Maximum Possible Score
A. Population within 1,000 feet of site		4		
B. Distance to nearest well		10		
C. Land use/zoning within 1 mile radius		3		
D. Distance to reservation boundary		6		
E. Critical environments within 1 mile radius of site		10		
F. Water quality of nearest surface water body		6		
G. Ground water use of uppermost aquifer		9		
H. Population served by surface water supply within 3 miles downstream of site		6		
I. Population served by ground-water supply within 3 miles of site		6		
		Subtotals	______	______

Receptors subscore (100 X factor score subtotal/maximum score subtotal) ______

II. WASTE CHARACTERISTICS

A. Select the factor score based on the estimated quantity, the degree of hazard, and the confidence level of the information.

1. Waste quantity (S = small, M = medium, L = large) ______
2. Confidence level (C = confirmed, S = suspected) ______
3. Hazard rating (H = high, M = medium, L = low) ______

Factor Subscore A (from 20 to 100 based on factor score matrix) ______

B. Apply persistence factor
Factor Subscore A X Persistence Factor = Subscore B

______ X ______ = ______

C. Apply physical state multiplier

Subscore B X Physical State Multiplier = Waste Characteristics Subscore

______ X ______ = ______

III. PATHWAYS

Rating Factor	Factor Rating (0-3)	Multiplier	Factor Score	Maximum Possible Score

A. If there is evidence of migration of hazardous contaminants, assign maximum factor subscore of 100 points for direct evidence or 80 points for indirect evidence. If direct evidence exists then proceed to C. If no evidence or indirect evidence exists, proceed to B.

Subscore ______

B. Rate the migration potential for 3 potential pathways: surface water migration, flooding, and ground-water migration. Select the highest rating, and proceed to C.

1. Surface water migration

Rating Factor	Factor Rating (0-3)	Multiplier	Factor Score	Maximum Possible Score
Distance to nearest surface water		8		
Net precipitation		6		
Surface erosion		8		
Surface permeability		6		
Rainfall intensity		8		
		Subtotals	______	______

Subscore (100 X factor score subtotal/maximum score subtotal) ______

2. Flooding

Rating Factor	Factor Rating (0-3)	Multiplier	Factor Score	Maximum Possible Score
Flooding		1		

Subscore (100 x factor score/3) ______

3. Ground-water migration

Rating Factor	Factor Rating (0-3)	Multiplier	Factor Score	Maximum Possible Score
Depth to ground water		8		
Net precipitation		6		
Soil permeability		3		
Subsurface flows		8		
Direct access to ground water		8		
		Subtotals	______	______

Subscore (100 x factor score subtotal/maximum score subtotal) ______

C. Highest pathway subscore.

Enter the highest subscore value from A, B-1, B-2 or B-3 above.

Pathways Subscore ______

IV. WASTE MANAGEMENT PRACTICES

A. Average the three subscores for receptors, waste characteristics, and pathways.

Receptors ______
Waste Characteristics ______
Pathways ______

Total ______ divided by 3 = ______
Gross Total Score

B. Apply factor for waste containment from waste management practices

Gross Total Score X Waste Management Practices Factor = Final Score

______ X ______ = ______

TABLE 1

HAZARD ASSESSMENT RATING METHODOLOGY GUIDELINES

I. RECEPTORS CATEGORY

Rating Factors	Rating Scale Levels: 0	1	2	3	Multiplier
A. Population within 1,000 feet (includes on-base facilities)	0	1 - 25	26 - 100	Greater than 100	4
B. Distance to nearest water well	Greater than 3 miles	1 to 3 miles	3,001 feet to 1 mile	0 to 3,000 feet	10
C. Land Use/Zoning (within 1 mile radius)	Completely remote (zoning not applicable)	Agricultural	Commercial or industrial	Residential	3
D. Distance to installation boundary	Greater than 2 miles	1 to 2 miles	1,001 feet to 1 mile	0 to 1,000 feet	6
E. Critical environments (within 1 mile radius)	Not a critical environment	Natural areas	Pristine natural areas; minor wetlands; preserved areas; presence of economically important natural resources susceptible to contamination.	Major habitat of an endangered or threatened species; presence of recharge area; major wetlands.	10
F. Water quality/use designation of nearest surface water body	Agricultural or Industrial use.	Recreation, propagation and management of fish and wildlife.	Shellfish propagation and harvesting.	Potable water supplies	6
G. Ground-Water use of uppermost aquifer	Not used, other sources readily available.	Commercial, industrial, or irrigation, very limited other water sources.	Drinking water, municipal water available.	Drinking water, no municipal water available; commercial, industrial, or irrigation, no other water source available.	9
H. Population served by surface water supplies within 3 miles downstream of site	0	1 - 50	51 - 1,000	Greater than 1,000	6
I. Population served by aquifer supplies within 3 miles of site	0	1 - 50	51 - 1,000	Greater than 1, 000	6

TABLE 1 (Continued)

HAZARD ASSESSMENT RATING METHODOLOGY GUIDELINES

II. WASTE CHARACTERISTICS

A-1 Hazardous Waste Quantity

S = Small quantity (<5 tons or 20 drums of liquid)
M = Moderate quantity (5 to 20 tons or 21 to 85 drums of liquid)
L = Large quantity (>20 tons or 85 drums of liquid)

A-2 Confidence Level of Information

C = Confirmed confidence level (minimum criteria below)

- o Verbal reports from interviewer (at least 2) or written information from the records.
- o Knowledge of types and quantities of wastes generated by shops and other areas on base.
- o Based on the above, a determination of the types and quantities of waste disposed of at the site.

S = Suspected confidence level

- o No verbal reports or conflicting verbal reports and no written information from the records.
- o Logic based on a knowledge of the types and quantities of hazardous wastes generated at the base, and a history of past waste disposal practices indicate that these wastes were disposed of at a site.

A-3 Hazard Rating

Hazard Category	Rating Scale Levels 0	1	2	3
Toxicity	Sax's Level 0	Sax's Level 1	Sax's Level 2	Sax's Level 3
Ignitability	Flash point greater than 200°F	Flash point at 140°F to 200°F	Flash point at 80°F to 140°F	Flash point less than 80°F
Radioactivity	At or below background levels	1 to 3 times background levels	3 to 5 times background levels	Over 5 times background levels

Use the highest individual rating based on toxicity, ignitability and radioactivity and determine the hazard rating.

Hazard Rating	Points
High (H)	3
Medium (M)	2
Low (L)	1

II. WASTE CHARACTERISTICS (Continued)

Waste Characteristics Matrix

Point Rating	Hazardous Waste Quantity	Confidence Level of Information	Hazard Rating
100	L	C	H
80	L	C	M
	M	C	H
70	L	S	H
60	S	C	H
	M	C	M
50	L	S	M
	L	C	L
	M	S	H
	S	C	M
40	S	S	H
	M	S	M
	M	C	L
	L	S	L
30	S	C	L
	M	S	L
	S	S	M
20	S	S	L

Notes:
For a site with more than one hazardous waste, the waste quantities may be added using the following rules:
Confidence Level
- o Confirmed confidence levels (C) can be added
- o Suspected confidence levels (S) can be added
- o Confirmed confidence levels cannot be added with suspected confidence levels

Waste Hazard Rating
- o Wastes with the same hazard rating can be added
- o Wastes with different hazard ratings can only be added in a downgrade mode, e.g., MCM + SCH = LCM if the total quantity is greater than 20 tons.

Example: Several wastes may be present at a site, each having an MCM designation (60 points). By adding the quantities of each waste, the designation may change to LCM (80 points). In this case, the correct point rating for the waste is 80.

B. Persistence Multiplier for Point Rating

Persistence Criteria	Multiply Point Rating From Part A by the Following
Metals, polycyclic compounds, and halogenated hydrocarbons	1.0
Substituted and other ring compounds	0.9
Straight chain hydrocarbons	0.8
Easily biodegradable compounds	0.4

C. Physical State Multiplier

Physical State	Multiply Point Total From Parts A and B by the Following
Liquid	1.0
Sludge	0.75
Solid	0.50

TABLE 1 (Continued)

HAZARD ASSESSMENT RATING METHODOLOGY GUIDELINES

III. PATHWAYS CATEGORY

A. Evidence of Contamination

Direct evidence is obtained from laboratory analyses of hazardous contaminants present above natural background levels in surface water, ground water, or air. Evidence should confirm that the source of contamination is the site being evaluated.

Indirect evidence might be from visual observation (i.e., leachate), vegetation stress, sludge deposits, presence of taste and odors in drinking water, or reported discharges that cannot be directly confirmed as resulting from the site, but the site is greatly suspected of being a source of contamination.

B-1 POTENTIAL FOR SURFACE WATER CONTAMINATION

Rating Factor	Rating Scale Levels 0	1	2	3	Multiplier
Distance to nearest surface water (includes drainage ditches and storm sewers)	Greater than 1 mile	2,001 feet to 1 mile	501 feet to 2,000 feet	0 to 500 feet	8
Net precipitation	Less than -10 in.	-10 to + 5 in.	+5 to +20 in.	Greater than +20 in.	6
Surface erosion	None	Slight	Moderate	Severe	8
Surface permeability	0% to 15% clay ($>10^{-2}$ cm/sec)	15% to 30% clay (10^{-2} to 10^{-4} cm/sec)	30% to 50% clay (10^{-4} to 10^{-6} cm/sec)	Greater than 50% clay ($<10^{-6}$ cm/sec)	6
Rainfall intensity based on 1 year 24-hr rainfall	<1.0 inch	1.0-2.0 inches	2.1-3.0 inches	>3.0 inches	8

B-2 POTENTIAL FOR FLOODING

Rating Factor	0	1	2	3	Multiplier
Floodplain	Beyond 100-year floodplain	In 25-year flood-plain	In 10-year flood-plain	Floods annually	1

B-3 POTENTIAL FOR GROUND-WATER CONTAMINATION

Rating Factor	0	1	2	3	Multiplier
Depth to ground water	Greater than 500 ft	50 to 500 feet	11 to 50 feet	0 to 10 feet	8
Net precipitation	Less than -10 in.	-10 to +5 in.	+5 to +20 in.	Greater than +20 in.	6
Soil permeability	Greater than 50% clay ($>10^{-6}$ cm/sec)	30% to 50% clay (10^{-4} to 10^{-6} cm/sec)	15% to 30% clay (10^{-2} to 10^{-4} cm/sec)	0% to 15% clay ($<10^{-2}$ cm/sec)	8
Subsurface flows	Bottom of site greater than 5 feet above high ground-water level	Bottom of site occasionally submerged	Bottom of site frequently submerged	Bottom of site located below mean ground-water level	8
Direct access to ground water (through faults, fractures, faulty well casings, subsidence fissures, etc.)	No evidence of risk	Low risk	Moderate risk	High risk	8

TABLE 1 (Continued)

HAZARD ASSESSMENT RATING METHODOLOGY GUIDELINES

IV. WASTE MANAGEMENT PRACTICES CATEGORY

A. This category adjusts the total risk as determined from the receptors, pathways, and waste characteristics categories for waste management practices and engineering controls designed to reduce this risk. The total risk is determined by first averaging the receptors, pathways, and waste characteristics subscores.

B. WASTE MANAGEMENT PRACTICES FACTOR

The following multipliers are then applied to the total risk points (from A):

Waste Management Practice	Multiplier
No containment	1.0
Limited containment	0.95
Fully contained and in full compliance	0.10

Guidelines for fully contained:

Landfills:

- o Clay cap or other impermeable cover
- o Leachate collection system
- o Liners in good condition
- o Adequate monitoring wells

Spills:

- o Quick spill cleanup action taken
- o Contaminated soil removed
- o Soil and/or water samples confirm total cleanup of the spill

Surface Impoundments:

- o Liners in good condition
- o Sound dikes and adequate freeboard
- o Adequate monitoring wells

Fire Proection Training Areas:

- o Concrete surface and berms
- o Oil/water separator for pretreatment of runoff
- o Effluent from oil/water separator to treatment plant

General Note: If data are not available or known to be complete the factor ratings under items I-A through I, III-B-1 or III-B-3, then leave blank for calculation of factor score and maximum possible score.

APPENDIX H

SITE HAZARD ASSESSMENT RATING FORMS

APPENDIX H

INDEX FOR HAZARD ASSESSMENT

METHODOLOGY FORMS

Spill Site No. 4	H-1
Landfill No. 4	H-3
Landfill No. 6	H-5
Landfill No. 5	H-7
Landfill No. 2	H-9
Spill Site No. 1	H-11
FPTA No. 2	H-13
Spill Site No. 2	H-15
Acid Dry Well	H-17
FPTA No. 1	H-19
Landfill No. 3	H-21
Spill Site No. 3	H-23
Spill Site No. 5	H-25
Spill Site No. 6	H-27

HAZARD ASSESSMENT RATING METHODOLOGY FORM

Name of site: Spill Site No. 4
Location: Building 1250
Date of Operation: 1982
Owner/Operator: FE Warren AFB
Comments/Description: TCE contamination; documented spill of 20 gallons;
Ground water contamination
Site Rated by: R.D.Stephens; D.A.Palombo; J.P.McAuliffe; E.J.Schroeder

I. RECEPTORS

Rating Factor	Factor Rating (0-3)	Multi- plier	Factor Score	Maximum Possible Score
A. Population within 1,000 feet of site	3	4	12	12
B. Distance to nearest well	2	10	20	30
C. Land use/zoning within 1 mile radius	3	3	9	9
D. Distance to installation boundary	2	6	12	18
E. Critical environments within 1 mile radius of site	3	10	30	30
F. Water quality of nearest surface water body	1	6	6	18
G. Ground water use of uppermost aquifer	2	9	18	27
H. Population served by surface water supply within 3 miles downstream of site	0	6	0	18
I. Population served by ground-water supply within 3 miles of site	3	6	18	18
Subtotals			125	180

Receptors subscore (100 x factor score subtotal/maximum score subtotal) 69

II. WASTE CHARACTERISTICS

A. Select the factor score based on the estimated quantity, the degree of hazard, and the confidence level of the information.

1. Waste quantity (small, medium, or large) M = medium
2. Confidence level (confirmed or suspected) C = confirmed
3. Hazard rating (low, medium, or high) H = high

Factor Subscore A (from 20 to 100 based on factor score matrix) 80

B. Apply persistence factor
Factor Subscore A x Persistence Factor = Subscore B

80 x 1.00 = 80

C. Apply physical state multiplier
Subscore B x Physical State Multiplier = Waste Characteristics Subscore

80 x 1.00 = 80

III. PATHWAYS

A. If there is evidence of migration of hazardous contaminants, assign maximum factor subscore of 100 points for direct evidence or 80 points for indirect evidence. If direct evidence exists then proceed to C. If no evidence or indirect evidence exists, proceed to B.

Subscore 100

B. Rate the migration potential for 3 potential pathways: surface water migration, flooding, and ground-water migration. Select the highest rating and proceed to C.

Rating Factor	Factor Rating (0-3)	Multi-plier	Factor Score	Maximum Possible Score
1. Surface Water Migration				
Distance to nearest surface water	2	8	16	24
Net precipitation	0	6	0	18
Surface erosion	1	8	8	24
Surface permeability	1	6	6	18
Rainfall intensity	1	8	8	24
Subtotals			38	108
Subscore (100 x factor score subtotal/maximum score subtotal)				35
2. Flooding	0	1	0	3
Subscore (100 x factor score/3)				0
3. Ground-water migration				
Depth to ground water	2	8	16	24
Net precipitation	0	6	0	18
Soil permeability	2	8	16	24
Subsurface flows	0	8	0	24
Direct access to ground water	1	8	8	24
Subtotals			40	114
Subscore (100 x factor score subtotal/maximum score subtotal)				35

C. Highest pathway subscore.

Enter the highest subscore value from A, B-1, B-2 or B-3 above.

Pathways Subscore 100

IV. WASTE MANAGEMENT PRACTICES

A. Average the three subscores for receptors, waste characteristics, and pathways.

Receptors		69		
Waste Characteristics		80		
Pathways		100		
Total	249	divided by 3 =	83	Gross total score

B. Apply factor for waste containment from waste management practices.

Gross total score x waste management practices factor = final score

83 x 1.00 = \ 83 \

FINAL SCORE

HAZARD ASSESSMENT RATING METHODOLOGY FORM

Name of site: Landfill No. 4
Location: Near Gate 2
Date of Operation: 1947 to 1959
Owner/Operator: FE Warren AFB
Comments/Description: Trench and fill

Site Rated by: R.D.Stephens; D.A.Palombo; J.P.McAuliffe; E.J.Schroeder

I. RECEPTORS

Rating Factor	Factor Rating (0-3)	Multi-plier	Factor Score	Maximum Possible Score
A. Population within 1,000 feet of site	1	4	4	12
B. Distance to nearest well	3	10	30	30
C. Land use/zoning within 1 mile radius	3	3	9	9
D. Distance to installation boundary	3	6	18	18
E. Critical environments within 1 mile radius of site	3	10	30	30
F. Water quality of nearest surface water body	1	6	6	18
G. Ground water use of uppermost aquifer	2	9	18	27
H. Population served by surface water supply within 3 miles downstream of site	0	6	0	18
I. Population served by ground-water supply within 3 miles of site	3	6	18	18
Subtotals			133	180

Receptors subscore (100 x factor score subtotal/maximum score subtotal) 74

II. WASTE CHARACTERISTICS

A. Select the factor score based on the estimated quantity, the degree of hazard, and the confidence level of the information.

1. Waste quantity (small, medium, or large) M = medium
2. Confidence level (confirmed or suspected) C = confirmed
3. Hazard rating (low, medium, or high) H = high

Factor Subscore A (from 20 to 100 based on factor score matrix) 80

B. Apply persistence factor
Factor Subscore A x Persistence Factor = Subscore B

80 x 1.00 = 80

C. Apply physical state multiplier
Subscore B x Physical State Multiplier = Waste Characteristics Subscore

80 x 1.00 = 80

III. PATHWAYS

A. If there is evidence of migration of hazardous contaminants, assign maximum factor subscore of 100 points for direct evidence or 80 points for indirect evidence. If direct evidence exists then proceed to C. If no evidence or indirect evidence exists, proceed to B.

Subscore 0

B. Rate the migration potential for 3 potential pathways: surface water migration, flooding, and ground-water migration. Select the highest rating and proceed to C.

Rating Factor	Factor Rating (0-3)	Multi-plier	Factor Score	Maximum Possible Score
1. Surface Water Migration				
Distance to nearest surface water	3	8	24	24
Net precipitation	0	6	0	18
Surface erosion	2	8	16	24
Surface permeability	1	6	6	18
Rainfall intensity	1	8	8	24
Subtotals			54	108
Subscore (100 x factor score subtotal/maximum score subtotal)				50
2. Flooding	1	1	1	3
Subscore (100 x factor score/3)				33
3. Ground-water migration				
Depth to ground water	3	8	24	24
Net precipitation	0	6	0	18
Soil permeability	2	8	16	24
Subsurface flows	2	8	16	24
Direct access to ground water	3	8	24	24
Subtotals			80	114
Subscore (100 x factor score subtotal/maximum score subtotal)				70

C. Highest pathway subscore.

Enter the highest subscore value from A, B-1, B-2 or B-3 above.

Pathways Subscore 70

IV. WASTE MANAGEMENT PRACTICES

A. Average the three subscores for receptors, waste characteristics, and pathways.

Receptors		74		
Waste Characteristics		80		
Pathways		70		
Total	224	divided by 3 =	75	Gross total score

B. Apply factor for waste containment from waste management practices.

Gross total score x waste management practices factor = final score

75 x 1.00 = 75

FINAL SCORE

HAZARD ASSESSMENT RATING METHODOLOGY FORM

Name of site: Landfill No. 6
Location: North of weapons storage area and Diamond Creek
Date of Operation: 1971 to present
Owner/Operator: FE Warren AFB
Comments/Description: Active only for Fly Ash ; closed for general refuse October 1984
Site Rated by: R.D.Stephens; D.A.Palombo; J.P.McAuliffe; E.J.Schroeder

I. RECEPTORS

Rating Factor	Factor Rating (0-3)	Multi-plier	Factor Score	Maximum Possible Score
A. Population within 1,000 feet of site	0	4	0	12
B. Distance to nearest well	3	10	30	30
C. Land use/zoning within 1 mile radius	3	3	9	9
D. Distance to installation boundary	3	6	18	18
E. Critical environments within 1 mile radius of site	3	10	30	30
F. Water quality of nearest surface water body	1	6	6	18
G. Ground water use of uppermost aquifer	2	9	18	27
H. Population served by surface water supply within 3 miles downstream of site	0	6	0	18
I. Population served by ground-water supply within 3 miles of site	3	6	18	18
Subtotals			129	180

Receptors subscore (100 x factor score subtotal/maximum score subtotal) 72

II. WASTE CHARACTERISTICS

A. Select the factor score based on the estimated quantity, the degree of hazard, and the confidence level of the information.

1. Waste quantity (small, medium, or large) L = large
2. Confidence level (confirmed or suspected) C = confirmed
3. Hazard rating (low, medium, or high) H = high

Factor Subscore A (from 20 to 100 based on factor score matrix) 100

B. Apply persistence factor
Factor Subscore A x Persistence Factor = Subscore B

100 x 1.00 = 100

C. Apply physical state multiplier
Subscore B x Physical State Multiplier = Waste Characteristics Subscore

100 x 1.00 = 100

III. PATHWAYS

A. If there is evidence of migration of hazardous contaminants, assign maximum factor subscore of 100 points for direct evidence or 80 points for indirect evidence. If direct evidence exists then proceed to C. If no evidence or indirect evidence exists, proceed to B.

Subscore 0

B. Rate the migration potential for 3 potential pathways: surface water migration, flooding, and ground-water migration. Select the highest rating and proceed to C.

Rating Factor	Factor Rating (0-3)	Multi-plier	Factor Score	Maximum Possible Score
1. Surface Water Migration				
Distance to nearest surface water	3	8	24	24
Net precipitation	0	6	0	18
Surface erosion	2	8	16	24
Surface permeability	1	6	6	18
Rainfall intensity	1	8	8	24
Subtotals			54	108
Subscore (100 x factor score subtotal/maximum score subtotal)				50
2. Flooding	0	1	0	3
Subscore (100 x factor score/3)				0
3. Ground-water migration				
Depth to ground water	2	8	16	24
Net precipitation	0	6	0	18
Soil permeability	2	8	16	24
Subsurface flows	0	8	0	24
Direct access to ground water	1	8	8	24
Subtotals			40	114
Subscore (100 x factor score subtotal/maximum score subtotal)				35

C. Highest pathway subscore.

Enter the highest subscore value from A, B-1, B-2 or B-3 above.

Pathways Subscore 50

IV. WASTE MANAGEMENT PRACTICES

A. Average the three subscores for receptors, waste characteristics, and pathways.

Receptors		72	
Waste Characteristics		100	
Pathways		50	
Total	222	divided by 3 =	74 Gross total score

B. Apply factor for waste containment from waste management practices.

Gross total score x waste management practices factor = final score

74 x 1.00 = 74

FINAL SCORE

HAZARD ASSESSMENT RATING METHODOLOGY FORM

Name of site: Landfill No. 5
Location: South of weapons storage area
Date of Operation: 1960 to 1970
Owner/Operator: FE Warren AFB
Comments/Description: Burn pit ; trench and fill for residue

Site Rated by: R.D.Stephens; D.A.Palombo; J.P.McAuliffe; E.J.Schroeder

---

I. RECEPTORS

Rating Factor	Factor Rating (0-3)	Multi-plier	Factor Score	Maximum Possible Score
A. Population within 1,000 feet of site	2	4	8	12
B. Distance to nearest well	3	10	30	30
C. Land use/zoning within 1 mile radius	3	3	9	9
D. Distance to installation boundary	3	6	18	18
E. Critical environments within 1 mile radius of site	3	10	30	30
F. Water quality of nearest surface water body	1	6	6	18
G. Ground water use of uppermost aquifer	2	9	18	27
H. Population served by surface water supply within 3 miles downstream of site	0	6	0	18
I. Population served by ground-water supply within 3 miles of site	3	6	18	18
Subtotals			137	180

Receptors subscore (100 x factor score subtotal/maximum score subtotal) 76

II. WASTE CHARACTERISTICS

A. Select the factor score based on the estimated quantity, the degree of hazard, and the confidence level of the information.

1. Waste quantity (small, medium, or large) M = medium
2. Confidence level (confirmed or suspected) C = confirmed
3. Hazard rating (low, medium, or high) H = high

Factor Subscore A (from 20 to 100 based on factor score matrix) 80

B. Apply persistence factor
Factor Subscore A x Persistence Factor = Subscore B

80 x 1.00 = 80

C. Apply physical state multiplier
Subscore B x Physical State Multiplier = Waste Characteristics Subscore

80 x 1.00 = 80

III. PATHWAYS

A. If there is evidence of migration of hazardous contaminants, assign *maximum* factor subscore of 100 points for direct evidence or 80 points for indirect evidence. If direct evidence exists then proceed to C. If no evidence or indirect evidence exists, proceed to B.

Subscore 0

B. Rate the migration potential for 3 potential pathways: surface water migration, flooding, and ground-water migration. Select the highest rating and proceed to C.

Rating Factor	Factor Rating (0-3)	Multi-plier	Factor Score	Maximum Possible Score
1. Surface Water Migration				
Distance to nearest surface water	2	8	16	24
Net precipitation	0	6	0	18
Surface erosion	2	8	16	24
Surface permeability	1	6	6	18
Rainfall intensity	1	8	8	24
Subtotals			46	108
Subscore (100 x factor score subtotal/maximum score subtotal)				43
2. Flooding	0	1	0	3
Subscore (100 x factor score/3)				0
3. Ground-water migration				
Depth to ground water	2	8	16	24
Net precipitation	0	6	0	18
Soil permeability	2	8	16	24
Subsurface flows	0	8	0	24
Direct access to ground water	1	8	8	24
Subtotals			40	114
Subscore (100 x factor score subtotal/maximum score subtotal)				35

C. Highest pathway subscore.

Enter the highest subscore value from A, B-1, B-2 or B-3 above.

Pathways Subscore 43

IV. WASTE MANAGEMENT PRACTICES

A. Average the three subscores for receptors, waste characteristics, and pathways.

Receptors	76		
Waste Characteristics	80		
Pathways	43		
Total 199 divided by 3 =		66	Gross total score

B. Apply factor for waste containment from waste management practices.

Gross total score x waste management practices factor = final score

66 x 1.00 = 66

FINAL SCORE

HAZARD ASSESSMENT RATING METHODOLOGY FORM

Name of site: Landfill No. 2
Location: Southwest of Transportation Complex (Building 800)
Date of Operation: 1900 to 1941
Owner/Operator: FE Warren AFB / Fort DA Russell
Comments/Description: Hardfill and refuse

Site Rated by: R.D.Stephens; D.A.Palombo; J.P.McAuliffe; E.J.Schroeder

I. RECEPTORS

Rating Factor	Factor Rating (0-3)	Multi-plier	Factor Score	Maximum Possible Score
A. Population within 1,000 feet of site	3	4	12	12
B. Distance to nearest well	1	10	10	30
C. Land use/zoning within 1 mile radius	3	3	9	9
D. Distance to installation boundary	2	6	12	18
E. Critical environments within 1 mile radius of site	3	10	30	30
F. Water quality of nearest surface water body	1	6	6	18
G. Ground water use of uppermost aquifer	2	9	18	27
H. Population served by surface water supply within 3 miles downstream of site	0	6	0	18
I. Population served by ground-water supply within 3 miles of site	3	6	18	18
Subtotals			115	180

Receptors subscore (100 x factor score subtotal/maximum score subtotal) 64

II. WASTE CHARACTERISTICS

A. Select the factor score based on the estimated quantity, the degree of hazard, and the confidence level of the information.

1. Waste quantity (small, medium, or large) S = small
2. Confidence level (confirmed or suspected) C = confirmed
3. Hazard rating (low, medium, or high) H = high

Factor Subscore A (from 20 to 100 based on factor score matrix) 60

B. Apply persistence factor
Factor Subscore A x Persistence Factor = Subscore B

60 x 1.00 = 60

C. Apply physical state multiplier
Subscore B x Physical State Multiplier = Waste Characteristics Subscore

60 x 1.00 = 60

III. PATHWAYS

A. If there is evidence of migration of hazardous contaminants, assign maximum factor subscore of 100 points for direct evidence or 80 points for indirect evidence. If direct evidence exists then proceed to C. If no evidence or indirect evidence exists, proceed to B.

Subscore 0

B. Rate the migration potential for 3 potential pathways: surface water migration, flooding, and ground-water migration. Select the highest rating and proceed to C.

Rating Factor	Factor Rating (0-3)	Multi-plier	Factor Score	Maximum Possible Score
1. Surface Water Migration				
Distance to nearest surface water	3	8	24	24
Net precipitation	0	6	0	18
Surface erosion	2	8	16	24
Surface permeability	1	6	6	18
Rainfall intensity	1	8	8	24
Subtotals			54	108
Subscore (100 x factor score subtotal/maximum score subtotal)				50
2. Flooding	0	1	0	3
Subscore (100 x factor score/3)				0
3. Ground-water migration				
Depth to ground water	3	8	24	24
Net precipitation	0	6	0	18
Soil permeability	2	8	16	24
Subsurface flows	2	8	16	24
Direct access to ground water	3	8	24	24
Subtotals			80	114
Subscore (100 x factor score subtotal/maximum score subtotal)				70

C. Highest pathway subscore.

Enter the highest subscore value from A, B-1, B-2 or B-3 above.

Pathways Subscore 70

IV. WASTE MANAGEMENT PRACTICES

A. Average the three subscores for receptors, waste characteristics, and pathways.

Receptors		64	
Waste Characteristics		60	
Pathways		70	
Total	194	divided by 3 =	65 Gross total score

B. Apply factor for waste containment from waste management practices.

Gross total score x waste management practices factor = final score

65 x 1.00 = 65

FINAL SCORE

HAZARD ASSESSMENT RATING METHODOLOGY FORM

Name of site: Spill Site No. 1
Location: BX Service Station
Date of Operation: 1973
Owner/Operator: FE Warren AFB
Comments/Description: 2,000 - 2,500 gallons of leaded Mogas

Site Rated by: R.D.Stephens; D.A.Palombo; J.P.McAuliffe; E.J.Schroeder

I. RECEPTORS

Rating Factor	Factor Rating (0-3)	Multi-plier	Factor Score	Maximum Possible Score
A. Population within 1,000 feet of site	3	4	12	12
B. Distance to nearest well	1	10	10	30
C. Land use/zoning within 1 mile radius	3	3	9	9
D. Distance to installation boundary	2	6	12	18
E. Critical environments within 1 mile radius of site	3	10	30	30
F. Water quality of nearest surface water body	1	6	6	18
G. Ground water use of uppermost aquifer	2	9	18	27
H. Population served by surface water supply within 3 miles downstream of site	0	6	0	18
I. Population served by ground-water supply within 3 miles of site	3	6	18	18
Subtotals			115	180

Receptors subscore (100 x factor score subtotal/maximum score subtotal) 64

II. WASTE CHARACTERISTICS

A. Select the factor score based on the estimated quantity, the degree of hazard, and the confidence level of the information.

1. Waste quantity (small, medium, or large) M = medium
2. Confidence level (confirmed or suspected) C = confirmed
3. Hazard rating (low, medium, or high) H = high

Factor Subscore A (from 20 to 100 based on factor score matrix) 80

B. Apply persistence factor
Factor Subscore A x Persistence Factor = Subscore B

80 x 1.00 = 80

C. Apply physical state multiplier
Subscore B x Physical State Multiplier = Waste Characteristics Subscore

80 x 1.00 = 80

III. PATHWAYS

A. If there is evidence of migration of hazardous contaminants, assign maximum factor subscore of 100 points for direct evidence or 80 points for indirect evidence. If direct evidence exists then proceed to C. If no evidence or indirect evidence exists, proceed to B.

Subscore 0

B. Rate the migration potential for 3 potential pathways: surface water migration, flooding, and ground-water migration. Select the highest rating and proceed to C.

Rating Factor	Factor Rating (0-3)	Multi-plier	Factor Score	Maximum Possible Score
1. Surface Water Migration				
Distance to nearest surface water	3	8	24	24
Net precipitation	0	6	0	18
Surface erosion	1	8	8	24
Surface permeability	1	6	6	18
Rainfall intensity	1	8	8	24
Subtotals			46	108
Subscore (100 x factor score subtotal/maximum score subtotal)				43
2. Flooding	0	1	0	3
Subscore (100 x factor score/3)				0
3. Ground-water migration				
Depth to ground water	2	8	16	24
Net precipitation	0	6	0	18
Soil permeability	2	8	16	24
Subsurface flows	0	8	0	24
Direct access to ground water	1	8	8	24
Subtotals			40	114
Subscore (100 x factor score subtotal/maximum score subtotal)				35

C. Highest pathway subscore.

Enter the highest subscore value from A, B-1, B-2 or B-3 above.

Pathways Subscore 43

IV. WASTE MANAGEMENT PRACTICES

A. Average the three subscores for receptors, waste characteristics, and pathways.

Receptors		64
Waste Characteristics		80
Pathways		43
Total	186	divided by 3 = 62 Gross total score

B. Apply factor for waste containment from waste management practices.

Gross total score x waste management practices factor = final score

62 x 1.00 = 62

FINAL SCORE

HAZARD ASSESSMENT RATING METHODOLOGY FORM

Name of site: Fire Protection Training Area No. 2
Location: West of 800 Transportation Complex
Date of Operation: 1965 to present
Owner/Operator: FE Warren AFB
Comments/Description: Waste flammables until 1974; clean JP - 4 until present

Site Rated by: R.D.Stephens; D.A.Palombo; J.P.McAuliffe; E.J.Schroeder

I. RECEPTORS

Rating Factor	Factor Rating (0-3)	Multi-plier	Factor Score	Maximum Possible Score
A. Population within 1,000 feet of site	3	4	12	12
B. Distance to nearest well	1	10	10	30
C. Land use/zoning within 1 mile radius	3	3	9	9
D. Distance to installation boundary	2	6	12	18
E. Critical environments within 1 mile radius of site	3	10	30	30
F. Water quality of nearest surface water body	1	6	6	18
G. Ground water use of uppermost aquifer	2	9	18	27
H. Population served by surface water supply within 3 miles downstream of site	0	6	0	18
I. Population served by ground-water supply within 3 miles of site	3	6	18	18
Subtotals			115	180

Receptors subscore (100 x factor score subtotal/maximum score subtotal) 64

II. WASTE CHARACTERISTICS

A. Select the factor score based on the estimated quantity, the degree of hazard, and the confidence level of the information.

1. Waste quantity (small, medium, or large) M = medium
2. Confidence level (confirmed or suspected) C = confirmed
3. Hazard rating (low, medium, or high) H = high

Factor Subscore A (from 20 to 100 based on factor score matrix) 80

B. Apply persistence factor
Factor Subscore A x Persistence Factor = Subscore B

80 x 1.00 = 80

C. Apply physical state multiplier
Subscore B x Physical State Multiplier = Waste Characteristics Subscore

80 x 1.00 = 80

III. PATHWAYS

A. If there is evidence of migration of hazardous contaminants, assign maximum factor subscore of 100 points for direct evidence or 80 points for indirect evidence. If direct evidence exists then proceed to C. If no evidence or indirect evidence exists, proceed to B.

Subscore 0

B. Rate the migration potential for 3 potential pathways: surface water migration, flooding, and ground-water migration. Select the highest rating and proceed to C.

Rating Factor	Factor Rating (0-3)	Multi-plier	Factor Score	Maximum Possible Score
1. Surface Water Migration				
Distance to nearest surface water	2	8	16	24
Net precipitation	0	6	0	18
Surface erosion	1	8	8	24
Surface permeability	1	6	6	18
Rainfall intensity	1	8	8	24
Subtotals			38	108
Subscore (100 x factor score subtotal/maximum score subtotal)				35
2. Flooding	0	1	0	3
Subscore (100 x factor score/3)				0
3. Ground-water migration				
Depth to ground water	2	8	16	24
Net precipitation	0	6	0	18
Soil permeability	2	8	16	24
Subsurface flows	0	8	0	24
Direct access to ground water	1	8	8	24
Subtotals			40	114
Subscore (100 x factor score subtotal/maximum score subtotal)				35

C. Highest pathway subscore.

Enter the highest subscore value from A, B-1, B-2 or B-3 above.

Pathways Subscore 35

===========

IV. WASTE MANAGEMENT PRACTICES

A. Average the three subscores for receptors, waste characteristics, and pathways.

Receptors		64		
Waste Characteristics		80		
Pathways		35		
Total	179	divided by 3 =	60	Gross total score

B. Apply factor for waste containment from waste management practices.

Gross total score x waste management practices factor = final score

60 x 1.00 = 60

FINAL SCORE

HAZARD ASSESSMENT RATING METHODOLOGY FORM

Name of site: Spill Site No. 2
Location: Building 810 - Yard
Date of Operation: September 1983
Owner/Operator: FE Warren AFB
Comments/Description: Waste oil accumulation; Point and spill site

Site Rated by: R.D.Stephens; D.A.Palombo; J.P.McAuliffe; E.J.Schroeder

I. RECEPTORS

Rating Factor	Factor Rating (0-3)	Multi-plier	Factor Score	Maximum Possible Score
A. Population within 1,000 feet of site	3	4	12	12
B. Distance to nearest well	1	10	10	30
C. Land use/zoning within 1 mile radius	3	3	9	9
D. Distance to installation boundary	2	6	12	18
E. Critical environments within 1 mile radius of site	3	10	30	30
F. Water quality of nearest surface water body	1	6	6	18
G. Ground water use of uppermost aquifer	2	9	18	27
H. Population served by surface water supply within 3 miles downstream of site	0	6	0	18
I. Population served by ground-water supply within 3 miles of site	3	6	18	18
Subtotals			115	180

Receptors subscore (100 x factor score subtotal/maximum score subtotal) 64

II. WASTE CHARACTERISTICS

A. Select the factor score based on the estimated quantity, the degree of hazard, and the confidence level of the information.

1. Waste quantity (small, medium, or large) M = medium
2. Confidence level (confirmed or suspected) C = confirmed
3. Hazard rating (low, medium, or high) H = high

Factor Subscore A (from 20 to 100 based on factor score matrix) 80

B. Apply persistence factor
Factor Subscore A x Persistence Factor = Subscore B

80 x 1.00 = 80

C. Apply physical state multiplier
Subscore B x Physical State Multiplier = Waste Characteristics Subscore

80 x 1.00 = 80

III. PATHWAYS

A. If there is evidence of migration of hazardous contaminants, assign maximum factor subscore of 100 points for direct evidence or 80 points for indirect evidence. If direct evidence exists then proceed to C. If no evidence or indirect evidence exists, proceed to B.

Subscore 0

B. Rate the migration potential for 3 potential pathways: surface water migration, flooding, and ground-water migration. Select the highest rating and proceed to C.

Rating Factor	Factor Rating (0-3)	Multi-plier	Factor Score	Maximum Possible Score
1. Surface Water Migration				
Distance to nearest surface water	2	8	16	24
Net precipitation	0	6	0	18
Surface erosion	1	8	8	24
Surface permeability	1	6	6	18
Rainfall intensity	1	8	8	24
Subtotals			38	108
Subscore (100 x factor score subtotal/maximum score subtotal)				35
2. Flooding	0	1	0	3
Subscore (100 x factor score/3)				0
3. Ground-water migration				
Depth to ground water	2	8	16	24
Net precipitation	0	6	0	18
Soil permeability	2	8	16	24
Subsurface flows	0	8	0	24
Direct access to ground water	1	8	8	24
Subtotals			40	114
Subscore (100 x factor score subtotal/maximum score subtotal)				35

C. Highest pathway subscore.

Enter the highest subscore value from A, B-1, B-2 or B-3 above.

Pathways Subscore 35

IV. WASTE MANAGEMENT PRACTICES

A. Average the three subscores for receptors, waste characteristics, and pathways.

Receptors		64		
Waste Characteristics		80		
Pathways		35		
Total	179	divided by 3 =	60	Gross total score

B. Apply factor for waste containment from waste management practices.

Gross total score x waste management practices factor = final score

60 x 1.00 = 60

FINAL SCORE

HAZARD ASSESSMENT RATING METHODOLOGY FORM

Name of site: Acid Dry Well
Location: West of Building 826
Date of Operation: Mid 1960's to present
Owner/Operator: FE Warren AFB
Comments/Description: Neutralized battery acid

Site Rated by: R.D.Stephens; D.A.Palombo; J.P.McAuliffe; E.J.Schroeder

I. RECEPTORS

Rating Factor	Factor Rating (0-3)	Multi-plier	Factor Score	Maximum Possible Score
A. Population within 1,000 feet of site	3	4	12	12
B. Distance to nearest well	1	10	10	30
C. Land use/zoning within 1 mile radius	3	3	9	9
D. Distance to installation boundary	2	6	12	18
E. Critical environments within 1 mile radius of site	3	10	30	30
F. Water quality of nearest surface water body	1	6	6	18
G. Ground water use of uppermost aquifer	2	9	18	27
H. Population served by surface water supply within 3 miles downstream of site	0	6	0	18
I. Population served by ground-water supply within 3 miles of site	3	6	18	18
Subtotals			115	180

Receptors subscore (100 x factor score subtotal/maximum score subtotal) 64

II. WASTE CHARACTERISTICS

A. Select the factor score based on the estimated quantity, the degree of hazard, and the confidence level of the information.

1. Waste quantity (small, medium, or large) M = medium
2. Confidence level (confirmed or suspected) C = confirmed
3. Hazard rating (low, medium, or high) H = high

Factor Subscore A (from 20 to 100 based on factor score matrix) 80

B. Apply persistence factor
Factor Subscore A x Persistence Factor = Subscore B

80 x 1.00 = 80

C. Apply physical state multiplier
Subscore B x Physical State Multiplier = Waste Characteristics Subscore

80 x 1.00 = 80

III. PATHWAYS

A. If there is evidence of migration of hazardous contaminants, assign maximum factor subscore of 100 points for direct evidence or 80 points for indirect evidence. *If direct evidence exists then proceed to C. If no evidence* or indirect evidence exists, proceed to B.

Subscore 0

B. Rate the migration potential for 3 potential pathways: surface water migration, flooding, and ground-water migration. Select the highest rating and proceed to C.

Rating Factor	Factor Rating (0-3)	Multi-plier	Factor Score	Maximum Possible Score
1. Surface Water Migration				
Distance to nearest surface water	2	8	16	24
Net precipitation	0	6	0	18
Surface erosion	1	8	8	24
Surface permeability	1	6	6	18
Rainfall intensity	1	8	8	24
Subtotals			38	108
Subscore (100 x factor score subtotal/maximum score subtotal)				35
2. Flooding	0	1	0	3
Subscore (100 x factor score/3)				0
3. Ground-water migration				
Depth to ground water	2	8	16	24
Net precipitation	0	6	0	18
Soil permeability	2	8	16	24
Subsurface flows	0	8	0	24
Direct access to ground water	1	8	8	24
Subtotals			40	114
Subscore (100 x factor score subtotal/maximum score subtotal)				35

C. Highest pathway subscore.

Enter the highest subscore value from A, B-1, B-2 or B-3 above.

Pathways Subscore 35

IV. WASTE MANAGEMENT PRACTICES

A. Average the three subscores for receptors, waste characteristics, and pathways.

Receptors		64
Waste Characteristics		80
Pathways		35
Total	179	divided by 3 = 60 Gross total score

B. Apply factor for waste containment from waste management practices.

Gross total score x waste management practices factor = final score

60 x 1.00 = 60

FINAL SCORE

HAZARD ASSESSMENT RATING METHODOLOGY FORM

Name of site: Fire Protection Training Area No. 1
Location: South of Crow Creek
Date of Operation: 1950 to 1965
Owner/Operator: FE Warren AFB
Comments/Description: Waste flammables for training

Site Rated by: R.D.Stephens; D.A.Palombo; J.P.McAuliffe; E.J.Schroeder

I. RECEPTORS

Rating Factor	Factor Rating (0-3)	Multi-plier	Factor Score	Maximum Possible Score
A. Population within 1,000 feet of site	1	4	4	12
B. Distance to nearest well	1	10	10	30
C. Land use/zoning within 1 mile radius	3	3	9	9
D. Distance to installation boundary	1	6	6	18
E. Critical environments within 1 mile radius of site	3	10	30	30
F. Water quality of nearest surface water body	1	6	6	18
G. Ground water use of uppermost aquifer	2	9	18	27
H. Population served by surface water supply within 3 miles downstream of site	0	6	0	18
I. Population served by ground-water supply within 3 miles of site	3	6	18	18
Subtotals			101	180

Receptors subscore (100 x factor score subtotal/maximum score subtotal) 56

II. WASTE CHARACTERISTICS

A. Select the factor score based on the estimated quantity, the degree of hazard, and the confidence level of the information.

1. Waste quantity (small, medium, or large) M = medium
2. Confidence level (confirmed or suspected) C = confirmed
3. Hazard rating (low, medium, or high) H = high

Factor Subscore A (from 20 to 100 based on factor score matrix) 80

B. Apply persistence factor
Factor Subscore A x Persistence Factor = Subscore B

80 x 1.00 = 80

C. Apply physical state multiplier
Subscore B x Physical State Multiplier = Waste Characteristics Subscore

80 x 1.00 = 80

III. PATHWAYS

A. If there is evidence of migration of hazardous contaminants, assign maximum factor subscore of 100 points for direct evidence or 80 points for indirect evidence. If direct evidence exists then proceed to C. If no evidence or indirect evidence exists, proceed to B.

Subscore 0

B. Rate the migration potential for 3 potential pathways: surface water migration, flooding, and ground-water migration. Select the highest rating and proceed to C.

Rating Factor	Factor Rating (0-3)	Multi-plier	Factor Score	Maximum Possible Score
1. Surface Water Migration				
Distance to nearest surface water	2	8	16	24
Net precipitation	0	6	0	18
Surface erosion	1	8	8	24
Surface permeability	1	6	6	18
Rainfall intensity	1	8	8	24
Subtotals			38	108
Subscore (100 x factor score subtotal/maximum score subtotal)				35
2. Flooding	0	1	0	3
Subscore (100 x factor score/3)				0
3. Ground-water migration				
Depth to ground water	2	8	16	24
Net precipitation	0	6	0	18
Soil permeability	2	8	16	24
Subsurface flows	0	8	0	24
Direct access to ground water	1	8	8	24
Subtotals			40	114
Subscore (100 x factor score subtotal/maximum score subtotal)				35

C. Highest pathway subscore.

Enter the highest subscore value from A, B-1, B-2 or B-3 above.

Pathways Subscore 35

IV. WASTE MANAGEMENT PRACTICES

A. Average the three subscores for receptors, waste characteristics, and pathways.

Receptors		56		
Waste Characteristics		90		
Pathways		35		
Total	171	divided by 3 =	57	Gross total score

B. Apply factor for waste containment from waste management practices.

Gross total score x waste management practices factor = final score

57 x 1.00 = 57

FINAL SCORE

HAZARD ASSESSMENT RATING METHODOLOGY FORM

Name of site: Landfill No. 3
Location: Southeast of Transportation Complex (Building 800)
Date of Operation: 1941 to 1947
Owner/Operator: FE Warren AFB
Comments/Description: Hardfill and general refuse

Site Rated by: R.D.Stephens; D.A.Palombo; J.P.McAuliffe; E.J.Schroeder

I. RECEPTORS

Rating Factor	Factor Rating (0-3)	Multi-plier	Factor Score	Maximum Possible Score
A. Population within 1,000 feet of site	0	4	0	12
B. Distance to nearest well	3	10	30	30
C. Land use/zoning within 1 mile radius	3	3	9	9
D. Distance to installation boundary	3	6	18	18
E. Critical environments within 1 mile radius of site	3	10	30	30
F. Water quality of nearest surface water body	1	6	6	18
G. Ground water use of uppermost aquifer	2	9	18	27
H. Population served by surface water supply within 3 miles downstream of site	0	6	0	18
I. Population served by ground-water supply within 3 miles of site	3	6	18	18
Subtotals			129	180

Receptors subscore (100 x factor score subtotal/maximum score subtotal) 72

II. WASTE CHARACTERISTICS

A. Select the factor score based on the estimated quantity, the degree of hazard, and the confidence level of the information.

1. Waste quantity (small, medium, or large) S = small
2. Confidence level (confirmed or suspected) C = confirmed
3. Hazard rating (low, medium, or high) H = high

Factor Subscore A (from 20 to 100 based on factor score matrix) 60

B. Apply persistence factor
Factor Subscore A x Persistence Factor = Subscore B

60 x 1.00 = 60

C. Apply physical state multiplier
Subscore B x Physical State Multiplier = Waste Characteristics Subscore

60 x 1.00 = 60

III. PATHWAYS

A. If there is evidence of migration of hazardous contaminants, assign maximum factor subscore of 100 points for direct evidence or 80 points for indirect evidence. If direct evidence exists then proceed to C. If no evidence or indirect evidence exists, proceed to B.

Subscore 0

B. Rate the migration potential for 3 potential pathways: surface water migration, flooding, and ground-water migration. Select the highest rating and proceed to C.

Rating Factor	Factor Rating (0-3)	Multi-plier	Factor Score	Maximum Possible Score
1. Surface Water Migration				
Distance to nearest surface water	2	8	16	24
Net precipitation	0	6	0	18
Surface erosion	1	8	8	24
Surface permeability	1	6	6	18
Rainfall intensity	1	8	8	24
Subtotals			38	108
Subscore (100 x factor score subtotal/maximum score subtotal)				35
2. Flooding	0	1	0	3
Subscore (100 x factor score/3)				0
3. *Ground-water migration*				
Depth to ground water	2	8	16	24
Net precipitation	0	6	0	18
Soil permeability	2	8	16	24
Subsurface flows	0	8	0	24
Direct access to ground water	1	8	8	24
Subtotals			40	114
Subscore (100 x factor score subtotal/maximum score subtotal)				35

C. Highest pathway subscore.

Enter the highest subscore value from A, B-1, B-2 or B-3 above.

Pathways Subscore 35

IV. WASTE MANAGEMENT PRACTICES

A. Average the three subscores for receptors, waste characteristics, and pathways.

Receptors	72		
Waste Characteristics	60		
Pathways	35		
Total 167 divided by 3 =		56	Gross total score

B. Apply factor for waste containment from waste management practices.

Gross total score x waste management practices factor = final score

56 x 1.00 = 56

FINAL SCORE

HAZARD ASSESSMENT RATING METHODOLOGY FORM

Name of site: Spill Site No. 3
Location: Building 338 - West
Date of Operation: 1980
Owner/Operator: FE Warren AFB
Comments/Description: 150 gallons battery acid

Site Rated by: R.D.Stephens; D.A.Palombo; J.P.McAuliffe; E.J.Schroeder

I. RECEPTORS

Rating Factor	Factor Rating (0-3)	Multi-plier	Factor Score	Maximum Possible Score
A. Population within 1,000 feet of site	3	4	12	12
B. Distance to nearest well	1	10	10	30
C. Land use/zoning within 1 mile radius	3	3	9	9
D. Distance to installation boundary	2	6	12	18
E. Critical environments within 1 mile radius of site	3	10	30	30
F. Water quality of nearest surface water body	1	6	6	18
G. Ground water use of uppermost aquifer	2	9	18	27
H. Population served by surface water supply within 3 miles downstream of site	0	6	0	18
I. Population served by ground-water supply within 3 miles of site	3	6	18	18
Subtotals			115	180

Receptors subscore (100 x factor score subtotal/maximum score subtotal) 64

II. WASTE CHARACTERISTICS

A. Select the factor score based on the estimated quantity, the degree of hazard, and the confidence level of the information.

1. Waste quantity (small, medium, or large) S = small
2. Confidence level (confirmed or suspected) C = confirmed
3. Hazard rating (low, medium, or high) H = high

Factor Subscore A (from 20 to 100 based on factor score matrix) 60

B. Apply persistence factor
Factor Subscore A x Persistence Factor = Subscore B

60 x 1.00 = 60

C. Apply physical state multiplier
Subscore B x Physical State Multiplier = Waste Characteristics Subscore

60 x 1.00 = 60

III. PATHWAYS

A. If there is evidence of migration of hazardous contaminants, assign maximum factor subscore of 100 points for direct evidence or 80 points for indirect evidence. If direct evidence exists then proceed to C. If no evidence or indirect evidence exists, proceed to B.

Subscore 0

B. Rate the migration potential for 3 potential pathways: surface water migration, flooding, and ground-water migration. Select the highest rating and proceed to C.

Rating Factor	Factor Rating (0-3)	Multi-plier	Factor Score	Maximum Possible Score
1. Surface Water Migration				
Distance to nearest surface water	2	8	16	24
Net precipitation	0	6	0	18
Surface erosion	1	8	8	24
Surface permeability	1	6	6	18
Rainfall intensity	1	8	8	24
Subtotals			38	108
Subscore (100 x factor score subtotal/maximum score subtotal)				35
2. Flooding	0	1	0	3
Subscore (100 x factor score/3)				0
3. Ground-water migration				
Depth to ground water	2	8	16	24
Net precipitation	0	6	0	18
Soil permeability	2	8	16	24
Subsurface flows	0	8	0	24
Direct access to ground water	1	8	8	24
Subtotals			40	114
Subscore (100 x factor score subtotal/maximum score subtotal)				35

C. Highest pathway subscore.

Enter the highest subscore value from A, B-1, B-2 or B-3 above.

Pathways Subscore 35

IV. WASTE MANAGEMENT PRACTICES

A. Average the three subscores for receptors, waste characteristics, and pathways.

Receptors	64	
Waste Characteristics	60	
Pathways	35	
Total 159 divided by 3 =		53 Gross total score

B. Apply factor for waste containment from waste management practices.

Gross total score x waste management practices factor = final score

53 x 1.00 = 53

FINAL SCORE

HAZARD ASSESSMENT RATING METHODOLOGY FORM

Name of site: Spill Site No. 5
Location: East of Building 336
Date of Operation: 1962 to present
Owner/Operator: FE Warren AFB
Comments/Description: Waste oil accumulation point

Site Rated by: R.D.Stephens; D.A.Palombo; J.P.McAuliffe; E.J.Schroeder

I. RECEPTORS

Rating Factor	Factor Rating (0-3)	Multi-plier	Factor Score	Maximum Possible Score
A. Population within 1,000 feet of site	3	4	12	12
B. Distance to nearest well	1	10	10	30
C. Land use/zoning within 1 mile radius	3	3	9	9
D. Distance to installation boundary	2	6	12	18
E. Critical environments within 1 mile radius of site	3	10	30	30
F. Water quality of nearest surface water body	1	6	6	18
G. Ground water use of uppermost aquifer	2	9	18	27
H. Population served by surface water supply within 3 miles downstream of site	0	6	0	18
I. Population served by ground-water supply within 3 miles of site	3	6	18	18
Subtotals			115	180

Receptors subscore (100 x factor score subtotal/maximum score subtotal) 64

II. WASTE CHARACTERISTICS

A. Select the factor score based on the estimated quantity, the degree of hazard, and the confidence level of the information.

1. Waste quantity (small, medium, or large) S = small
2. Confidence level (confirmed or suspected) C = confirmed
3. Hazard rating (low, medium, or high) H = high

Factor Subscore A (from 20 to 100 based on factor score matrix) 60

B. Apply persistence factor
Factor Subscore A x Persistence Factor = Subscore B

60 x 1.00 = 60

C. Apply physical state multiplier
Subscore B x Physical State Multiplier = Waste Characteristics Subscore

60 x 1.00 = 60

III. PATHWAYS

A. If there is evidence of migration of hazardous contaminants, assign maximum factor subscore of 100 points for direct evidence or 80 points for indirect evidence. If direct evidence exists then proceed to C. If no evidence or indirect evidence exists, proceed to B.

Subscore 0

B. Rate the migration potential for 3 potential pathways: surface water migration, flooding, and ground-water migration. Select the highest rating and proceed to C.

Rating Factor	Factor Rating (0-3)	Multi-plier	Factor Score	Maximum Possible Score
1. Surface Water Migration				
Distance to nearest surface water	2	8	16	24
Net precipitation	0	6	0	18
Surface erosion	1	8	8	24
Surface permeability	1	6	6	18
Rainfall intensity	1	8	8	24
Subtotals			38	108
Subscore (100 x factor score subtotal/maximum score subtotal)				35
2. Flooding	0	1	0	3
Subscore (100 x factor score/3)				0
3. Ground-water migration				
Depth to ground water	2	8	16	24
Net precipitation	0	6	0	18
Soil permeability	2	8	16	24
Subsurface flows	0	8	0	24
Direct access to ground water	1	8	8	24
Subtotals			40	114
Subscore (100 x factor score subtotal/maximum score subtotal)				35

C. Highest pathway subscore.

Enter the highest subscore value from A, B-1, B-2 or B-3 above.

Pathways Subscore 35

IV. WASTE MANAGEMENT PRACTICES

A. Average the three subscores for receptors, waste characteristics, and pathways.

Receptors		64
Waste Characteristics		60
Pathways		35
Total	159	divided by 3 = 53 Gross total score

B. Apply factor for waste containment from waste management practices.

Gross total score x waste management practices factor = final score

53 x 1.00 = 53

FINAL SCORE

HAZARD ASSESSMENT RATING METHODOLOGY FORM

Name of site: Spill Site No. 6
Location: Building 316 - Courtyard
Date of Operation: 1962 to present
Owner/Operator: FE Warren AFB
Comments/Description: Waste oil accumulation point

Site Rated by: R.D.Stephens; D.A.Palombo; J.P.McAuliffe; E.J.Schroeder

I. RECEPTORS

Rating Factor	Factor Rating (0-3)	Multi-plier	Factor Score	Maximum Possible Score
A. Population within 1,000 feet of site	3	4	12	12
B. Distance to nearest well	1	10	10	30
C. Land use/zoning within 1 mile radius	3	3	9	9
D. Distance to installation boundary	2	6	12	18
E. Critical environments within 1 mile radius of site	3	10	30	30
F. Water quality of nearest surface water body	1	6	6	18
G. Ground water use of uppermost aquifer	2	9	18	27
H. Population served by surface water supply within 3 miles downstream of site	0	6	0	18
I. Population served by ground-water supply within 3 miles of site	3	6	18	18
Subtotals			115	180

Receptors subscore (100 x factor score subtotal/maximum score subtotal) 64

II. WASTE CHARACTERISTICS

A. Select the factor score based on the estimated quantity, the degree of hazard, and the confidence level of the information.

1. Waste quantity (small, medium, or large) S = small
2. Confidence level (confirmed or suspected) C = confirmed
3. Hazard rating (low, medium, or high) H = high

Factor Subscore A (from 20 to 100 based on factor score matrix) 60

B. Apply persistence factor
Factor Subscore A x Persistence Factor = Subscore B

60 x 1.00 = 60

C. Apply physical state multiplier
Subscore B x Physical State Multiplier = Waste Characteristics Subscore

60 x 1.00 = 60

III. PATHWAYS

A. If there is evidence of migration of hazardous contaminants, assign maximum factor subscore of 100 points for direct evidence or 80 points for indirect evidence. If direct evidence exists then proceed to C. If no evidence or indirect evidence exists, proceed to B.

Subscore 0

B. Rate the migration potential for 3 potential pathways: surface water migration, flooding, and ground-water migration. Select the highest rating and proceed to C.

Rating Factor	Factor Rating (0-3)	Multi-plier	Factor Score	Maximum Possible Score
1. Surface Water Migration				
Distance to nearest surface water	2	8	16	24
Net precipitation	0	6	0	18
Surface erosion	1	8	8	24
Surface permeability	1	6	6	18
Rainfall intensity	1	8	8	24
Subtotals			38	108
Subscore (100 x factor score subtotal/maximum score subtotal)				35
2. Flooding	0	1	0	3
Subscore (100 x factor score/3)				0
3. Ground-water migration				
Depth to ground water	2	8	16	24
Net precipitation	0	6	0	18
Soil permeability	2	8	16	24
Subsurface flows	0	8	0	24
Direct access to ground water	1	8	8	24
Subtotals			40	114
Subscore (100 x factor score subtotal/maximum score subtotal)				35

C. Highest pathway subscore.

Enter the highest subscore value from A, B-1, B-2 or B-3 above.

Pathways Subscore 35

IV. WASTE MANAGEMENT PRACTICES

A. Average the three subscores for receptors, waste characteristics, and pathways.

Receptors	64	
Waste Characteristics	60	
Pathways	35	
Total 159 divided by 3 =		53 Gross total score

B. Apply factor for waste containment from waste management practices.

Gross total score x waste management practices factor = final score

53 x 1.00 = 53

FINAL SCORE

APPENDIX I

GLOSSARY OF TERMINOLOGY AND ABBREVIATIONS

GLOSSARY OF TERMINOLOGY AND ABBREVIATIONS

AF: Air Force.

AFB: Air Force Base.

AFCS: Air Force Communications Service.

AFFF: Aqueous Film Forming Foam, a fire extinguishing agent. AFFF concentrates include fluorinated surfactants plus foam stabilizers diluted with water to a 3 to 6% solution.

Ag: Chemical symbol for silver.

AGE: Aerospace Ground Equipment.

Al: Chemical symbol for aluminum.

ALC: Air Logistics Center.

ALLUVIUM: Materials eroded, transported and deposited by streams.

ANCOIC: Assistant Non-Commissioned officer In-Charge

ANTICLINE: A fold in which layered strata are inclined down and away from the axes.

AROMATIC: Description of organic chemical compounds in which the carbon atoms are arranged into a ring with special electron stability associated. Aromatic compounds are often more reactive than non-aromatics.

ARTESIAN: Ground water contained under hydrostatic pressure.

AQUICLUDE: Poorly permeable formation that impedes ground-water movement and does not yield to a well or spring.

AQUIFER: A geologic formation, group of formations, or part of a formation that is capable of yielding water to a well or spring.

AQUITARD: A geologic unit which impedes ground-water flow.

ATC: Air Training Command.

AVGAS: Aviation Gasoline.

Ba: Chemical symbol for barium.

BEDROCK: Any solid rock exposed at the surface of the earth or overlain by unconsolidated material.

BEE: Bioenvironmental Engineer.

BES: Bioenvironmental Engineering Services.

BIOACCUMULATE: Tendency of elements or compounds to accumulate or build up in the tissues of living organisms when they are exposed to these elements in their environments, e.g., heavy metals.

BIODEGRADABLE: The characteristic of a substance to be broken down from complex to simple compounds by microorganisms.

BX: Base Exchange.

$CaCO_3$: Chemical symbol for calcium carbonate.

Cd: Chemical symbol for cadmium.

CE: Civil Engineering.

CERCLA: Comprehensive Environmental Response, Compensation and Liability Act.

CES: Civil Engineering Squadron.

CIRCA: About; used to indicate an approximate date.

CLOSURE: The completion of a set of rigidly defined functions for a hazardous waste facility no longer in operation.

CN: Chemical symbol for cyanide.

COD: Chemical Oxygen Demand, a measure of the amount of oxygen required to oxidize organic and oxidizable inorganic compounds in water.

COE: Corps of Engineers.

COLLUVIUM: Sediments that have moved down slope primarily under the influence of gravity or as periodic, unchannelized flow. It frequently includes large boulders or other fragments which contrast this matrial to alluvium, material deposited by channelized flow which results in some degree of sorting according to particle size.

CONFINED AQUIFER: An aquifer bounded above and below by impermeable strata or by geologic units of distinctly lower permeability than that of the aquifer itself.

CONFINING UNIT: An aquitard or other poorly permeable layer which restricts the movement of ground water.

CONTAMINATION: The degradation of natural water quality to the extent that its usefulness is impaired; there is no implication of any specific limits since the degree of permissible contamination depends upon the intended end use or uses of the water.

Cr: Chemical symbol for chromium.

Cu: Chemical symbol for copper.

DEQPPM: Defense Environmental Quality Program Policy Memorandum

DET: Detachment.

DISPOSAL FACILITY: A facility or part of a facility at which hazardous waste is intentionally placed into or on land or water, and at which waste will remain after closure.

DISPOSAL OF HAZARDOUS WASTE: The discharge, deposit, injection, dumping, spilling, or placing of any hazardous waste into or on land or water so that such waste or any constituent thereof may enter the environment or be emitted into the air or discharged into any waters, including ground water.

DOD: Department of Defense.

DOWNGRADIENT: In the direction of decreasing hydraulic static head; the direction in which ground water flows.

DPDO: Defense Property Disposal Office, previously included Redistribution and Marketing (R&M) and Salvage. DPDO is now titled the Defense Reutilization and Marketing Agency.

DUMP: An uncovered land disposal site where solid and/or liquid wastes are deposited with little or no regard for pollution control or aesthetics; dumps are susceptible to open burning and are exposed to the elements, disease vectors and scavengers.

EFFLUENT: A liquid waste discharge from a manufacturing or treatment process, in its natural state, or partially or completely treated, that discharges into the environment.

ELECTRICAL RESISTIVITY (ER): Specialized equipment designed to produce an electrical current through subsurface geologic strata. The instrument and the technique permit the operator to examine conditions at specific depths below land surface. Subsurface contrasts indicative of specific geologic or hydrologic conditions may be obtained through correlation of the ER data with known site information such as that provided by test borings or well construction logs.

EOD: Explosive Ordnance Disposal.

EP: Extraction Procedure, the EPA's standard laboratory procedure for leachate generation.

EPA: U.S. Environmental Protection Agency.

EPHEMERAL: Short-lived or temporary.

EPHEMERAL AQUIFER: A water-bearing zone typically located near the surface which normally contains water seasonally.

EROSION: The wearing away of land surface by wind, water, or chemical processes.

ES: Engineering-Science, Inc.

FAA: Federal Aviation Administration.

FACILITY (As Applied to Hazardous Wastes): Any land and appurtenances thereon and thereto used for the treatment, storage and/or disposal of hazardous wastes.

FAULT: A fracture in rock along which the adjacent rock surfaces are differentially displaced.

Fe: Chemical symbol for iron.

FLOW PATH: The direction or movement of ground water as governed principally by the hydraulic gradient.

FMMS: Field Missile Maintenance Squadron.

FPTA: Fire Protection Training Area.

FTA: Fire Training Area.

GC/MS: Gas chromatograph/mass spectrophotometer, a laboratory procedure for identifying unknown compounds.

GEOPHYSICS: (Geophysical survey) the use of one or more geophysical instruments or methods to measure specific properties of the earth's subsurface through indirect means. Geophysical equipment may include electrical resistivity, geiger counter, magnetometer, metal detector, electromagnetic conductivity, magnetic susceptibility, etc. Geophysics seeks to provide specific measurements of the earth's magnetic field, the electrical properties of specific geologic strata, radioactivity, etc.

GLACIAL TILL: Unsorted and unstratified drift consisting of clay, sand, gravel and boulders which is deposited by or underneath a glacier.

GROUND WATER: Water beneath the land surface in the saturated zone that is under atmospheric or artesian pressure.

GROUND-WATER RESERVOIR: The earth materials and the intervening open spaces that contain ground water.

HALOGEN: The class of chemical elements including fluorine, chlorine, bromine, and iodine.

HARDFILL: Disposal sites receiving construction debris, wood, miscellaneous spoil material.

HARM: Hazard Assessment Rating Methodology.

HAZARDOUS SUBSTANCE: Under CERCLA, the definition of hazardous substance includes:

1. All substances regulated under Paragraphs 311 and 307 of the Clean Water Act (except oil);

2. All substances regulated under Paragraph 3001 of the Solid Waste Disposal Act;

3. All substances regulated under Paragraph 112 of the Clean Air Act;

4. All substances which the Administrator of EPA has acted against under Paragraph 7 of the Toxic Substance Control Act;

5. Additional substances designated under Paragraph 102 of CERCLA.

HAZARDOUS WASTE: As defined in RCRA, a solid waste, or combination of solid wastes, which because of its quantity, concentration, or physical, chemical or infectious characteristics may cause or significantly contribute to an increase in mortality or an increase in serious, irreversible, or incapacitating reversible illness; or pose a substantial present or potential hazard to human health or the environment when improperly treated, stored, transported, or disposed of, or otherwise managed.

HAZARDOUS WASTE GENERATION: The act or process of producing a hazardous waste.

HEAVY METALS: Metallic elements, including the transition series, which include many elements required for plant and animal nutrition in trace concentrations but which become toxic at higher concentrations.

Hg: Chemical symbol for mercury.

HQ: Headquarters.

HWAP: Hazardous Waste Accumulation Point.

HWMF: Hazardous Waste Management Facility.

HYDROCARBONS: Organic chemical compounds composed of hydrogen and carbon atoms chemically bonded. Hydrocarbons may be straight chain, cyclic, branched chain, aromatic, or polycyclic, depending upon arrangement of carbon atoms. Halogenated hydrocarbons are hydrocarbons in which one or more hydrogen atoms has been replaced by a halogen atom.

INCOMPATIBLE WASTE: A waste unsuitable for commingling with another waste or material because the commingling might result in generation of extreme heat or pressure, explosion or violent reaction, fire, formation of substances which are shock sensitive, friction sensitive, or otherwise have the potential for reacting violently, formation of toxic dusts, mists, fumes, and gases, volatilization of ignitable or toxic chemicals due to heat generation in such a manner that the likelihood of contamination of ground water or escape of the substance into the environment is increased, any other reaction which might result in not meeting the air, human health, and environmental standards.

INFILTRATION: The movement of water through the soil surface into the ground.

IRP: Installation Restoration Program.

ISOPACH: Graphic presentation of geologic data, including lines of equal unit thickness that may be based on confirmed (drill hole) data or indirect geophysical measurement.

JP-4: Jet Propulsion Fuel Number Four; contains both kerosene and gasoline fractions.

JP-5: Jet Propulsion Fuel Number Five; consists of high boiling kerosene fractions.

LANDFILL: A land disposal site used for disposing solid and semi-solid materials. May refer either to a sanitary landfill or dump.

LEACHATE: A solution resulting from the separation or dissolving of soluble or particulate constituents from solid waste or other man-placed medium by percolation of water.

LEACHING: The process by which soluble materials in the soil, such as nutrients, pesticide chemicals or contaminants, are washed into a lower layer of soil or are dissolved and carried away by water.

LENTICULAR: A bed or rock stratum or body that is lens-shaped.

LINER: A continous layer of natural or man-made materials beneath or on the sides of a surface impoundment, landfill, or landfill cell which restricts the downward or lateral escape of hazardous waste, hazardous waste constituents or leachate.

LITHOLOGY: The description of the physical character of a rock.

LOESS: An essentially unconsolidated unstratified calcareous silt; commonly homogeneous, permeable and buff to gray in color.

m: Milli (10^{-3}).

MAC: Military Airlift Command.

MAGNETOMETER (MG): A device capable of measuring localized variations in the earth's magnetic field that may be due to disturbed areas such as backfilled trenches, buried objects, etc. Measurements may be obtained at points located on a grid pattern so that the data can be contoured, revealing the location, size and intensity of the suspected anomaly.

MAINT: Recording System Maintenance.

MEK: Methyl Ethyl Ketone.

METALS: See "Heavy Metals".

mgd: Million Gallons per Day.

MIBK: Methyl Isobutyl Ketone.

MICRO: u

ug/1: Micrograms per liter.

mg/l: Milligrams per liter.

MOGAS: Motor gasoline.

Mn: Chemical symbol for manganese.

MONITORING WELL: A well used to measure ground-water levels and to obtain ground-water samples for water quality analyses. As distinguished from observation wells, monitoring wells are often designed for longer term operations. They are constructed of materials for the site-specific climatic, hydrogeologic and contaminant conditions.

MSL: Mean Sea Level.

MUNITION ITEMS: Munitions or portions of munitions having an explosive potential.

MUNITIONS RESIDUE: Non-explosive segments of waste munitions (i.e., bomb casings).

MWR: Morale Welfare and Recreation.

NCO: Non-commissioned Officer.

NCOIC: Non-commissioned Officer In-Charge.

NET PRECIPITATION: The amount of annual precipitation minus annual evaporation.

NGVD: National Geodetic Vertical Datum of 1929. A national datum system, tied to Mean Sea Level, but referenced primarily to land-based benchmarks.

Ni: Chemical symbol for nickel.

NOAA: National Oceanic and Atmospheric Administration.

NON-CALCAREOUS: Not bea..ng calcium carbonate ($CaCO_3$) a characteristic mineral of marine paleoenvironment.

NPDES: National Pollutant Discharge Elimination System.

OBSERVATION WELL: An informally designed cased well, open to a specific geologic unit or formation, designed to allow the measurement of physical ground-water properties within the zone or unit of interest. Observation wells are designed to permit the measurement of water levels and in-situ parameters such as ground-water (flow velocity and flow direction. Not to be confused with a monitoring well, a well designed to permit accurate ground-water quality monitoring. Monitoring wells are constructed of materials compatible with site-specific climatic, hydrogeologic and contaminant conditions. monitoring well installation and construction is planned to have minimal impacts on apparent ground-water quality and will often be for longer term operation compared with observation wells.

OEHL: USAF Occupational and Environmental Health Laboratory.

OIC: Officer-In-Charge.

OMMS: Organizational Missile Maintenance Squadron.

OPNS: Operations.

ORGANIC: Being, containing or relating to carbon compounds, especially in which hydrogen is attached to carbon.

OSI: Office of Special Investigations.

O&G: Symbols for oil and grease.

OUT CROP: Zone or area of exposure where a geologic unit or formation occurs at or near land surface. "Outcrop area" is an important factor in hydrogeologic studies as this zone usually corresponds to the point where significant recharge occurs. When this term is used as an intransitive verb: "Where the unit crops out....."

OVA: Organic Vapor Analyzer

OXIDIZER: Material necessary to support combustion of fuel.

Pb: Chemical symbol for lead.

PCB: Polychlorinated Biphenyl; liquids used as a dielectrics in electrical equipment.

PD-680: Cleaning solvent; petroleum distillate, Stoddard solvent.

PERCHED WATER TABLE: A water table above a relatively impermeable zone underlain by unsaturated rocks of sufficient permeability to allow ground-water movement.

PERCOLATION: Movement of moisture by gravity or hydrostatic pressure through interstices of unsaturated rock or soil.

PERMEABILITY: The relative rate of water flow through a porous medium. The USDA, Soil Conservation Service describes permeability qualitatively as follows:

very slow	<0.06	inches/hour
slow	0.06 to 0.2	inches/hour
moderately slow	0.2 to 0.6	inches/hour
moderate	0.6 to 2.0	inches/hour
moderately rapid	2.0 to 6.0	inches/hour
rapid	6.0 to 20	inches/hour
very rapid	>20	inches/hour

PERSISTENCE: As applied to chemicals, those which are very stable and remain in the environment in their original form for an extended period of time.

PESTICIDE: An agent used to destroy pests. Pesticides include such specialty groups as herbicides, fungicides, insecticides, etc.

pH: Negative logarithm of hydrogen ion concentration.

PL: Public Law.

PMEL: Precision Measurement Equipment Lab.

POL: Petroleum, Oils and Lubricants.

POLLUTANT: Any introduced gas, liquid or solid that makes a resource unfit for a specific purpose.

POLYCYCLIC COMPOUND: All compounds in which carbon atoms are arranged into two or more rings, usually aromatic in nature.

POTENTIALLY ACTIVE FAULT: A fault along which movement has occurred within the last 25-million years.

POTENTIOMETRIC SURFACE: The imaginery surface to which water in an artesian aquifer would rise in tightly screened wells penetrating it.

ppb: Parts per billion by weight.

ppm: Parts per million by weight.

PRECIPITATION: Rainfall.

PREL: Power Refrigeration Electronic Lab

PROPELLANT: fuels, oxiders and monopropellants.

QUATERNARY MATERIALS: The second period of the Cenozoic geologic era, following the Tertiary, and including the last 2-3 million years.

QAE: Quality Assurance Evaluator.

RCRA: Resource Conservation and Recovery Act.

RECEPTORS: The potential impact group or resource for a waste contamination source.

RECHARGE AREA: A surface area in which surface water or precipitation percolates through the unsaturated zone and eventually reaches the zone of saturation. Recharge areas may be natural or manmade.

RECHARGE: The addition of water to the ground-water system by natural or artificial processes.

RESISTIVITY: See Electrical Resistivity

RIPARIAN: Living or located on a riverbank.

RM: Resource Management.

SAC: Strategic Air Command.

SANITARY LANDFILL: A land disposal site using an engineered method of disposing solid wastes on land in a way that minimizes environmental hazards.

SATURATED ZONE: That part of the earth's crust in which all voids are filled with water.

SAX'S TOXICITY: A rating method for evaluating the toxicity of chemical materials.

SCS: U.S. Department of Agriculture Soil Conservation Service.

SEISMICITY: Pertaining to earthquakes or earth vibrations.

SLUDGE: The solid residue resulting from a manufacturing or wastewater treatment process which also produces a liquid stream. The residue which accumulates in liquid fuel storage tanks.

SOLE SOURCE: As in aquifer. The only source of potable water supplies of acceptable quality available in adequate quantities for a significant population. Sole source is a legal term which permits use control of the aquifer by designated regulatory authorities.

SMART: Structural maintenance and repair team.

SOLID WASTE: Any garbage, refuse, or sludge from a waste treatment plant, water supply treatment, or air pollution control facility and other discarded material, including solid, liquid, semi-solid, or contained gaseous material resulting from industrial, commercial, mining, or agricultural operations and from community activities, but does not include solid or dissolved materials in domestic sewage; solid or dissolved materials in irrigation return flows; industrial discharges which are point source subject to permits under Section 402 of the Federal Water Pollution Control Act, as amended (86 USC 880); or source, special nuclear, or by-product material as defined by the Atomic Energy Act of 1954 (68 USC 923).

SPILL: Any unplanned release or discharge of a hazardous waste onto or into the air, land, or water.

STORAGE OF HAZARDOUS WASTE: Containment, either on a temporary basis or for a longer period, in such a manner as not to constitute disposal of such hazardous waste.

STP: Sewage Treatment Plant.

SUPS: Supply Squadron.

TCA: 1,1,1,-Tetrachloroethane.

TCE: Trichloroethylene, a solvent and suspected carcinogen.

TDS: Total Dissolved Solids.

TOC: Total Organic Carbon.

TOXICITY: The ability of a material to produce injury or disease upon exposure, ingestion, inhalation, or assimilation by a living organism.

TRANS: Transportation Squadron.

TRANSMISSIVITY: The rate at which water is transmitted through a unit width of aquifer under a unit hydraulic gradient.

TREATMENT OF HAZARDOUS WASTE: Any method, technique, or process including neutralization designed to change the physical, chemical, or biological character or composition of any hazardous waste so as to neutralize the waste or so as to render the waste nonhazardous.

TSD: Treatment, storage or disposal sites/methods.

UPGRADIENT: In the direction of increasing hydraulic static head; the direction opposite to the prevailing flow of ground-water.

US: United States.

USAF: United States Air Force.

USAFSS: United States Air Force Security Service.

USDA: United States Department of Agriculture.

USFWS: United States Fish and Wildlife Service.

USGS: United States Geological Survey.

WATER TABLE: Surface of a body of unconfined ground water at which the pressure is equal to that of the atmosphere.

WWTP: Wastewater Treatment Plant.

Zn: Chemical symbol for zinc.

APPENDIX J

REFERENCES

APPENDIX J

REFERENCES

Avery, Charles and R.A., Pettijohn, 1984. Generalized Potentiometric Surface Map of the High Plains Aquifer in Wyoming, 1981. Water Resources Investigations Report 84-4033.

Babcock, H.M., and Bjorklund, L.J., 1956. Groundwater Geology of Parts of Laramie and Albany Counties, Wyoming and Weld County, Colorado. U.S. Geological Survey Water Supply Paper 1367.

Babcock, H.M., and Rapp, J.R., 1952. Reconnaissance of the Geology and Groundwater Resources of the Horse Creek-Bear Creek area, Laramie and Goshen Counties, Wyoming. U.S. Geological Survey Circular 162.

Bjorklund, L.J., 1957, Geology and Groundwater Resources of the Lower Lodgepole Creek Drainage Basin, Nebraska, with a section on Chemical Quality of Water by E.R. Jochens. U.S. Geological Survey Water Supply Paper 1410.

Bjorklund, L.J., 1959, Geology and Groundwater Resources of the Upper Lodgepole Creek Drainage Basin, Wyoming. U.S. Geological Survey Water Supply Paper 1483.

Borchert, W.B., 1976. Geohydrology of the Albin and LaGrange Areas, Southeastern Wyoming. U.S. Geological Survey Water Resources Investigations 76-118.

Cady, R.C., 1935. Report on the Test Well at the Veterans Administration Facility, Cheyenne, Wyoming. U.S. Geological Survey, Open File Report.

Cooley, M.E., and Crist, M.A., 1980. Generalized Fence Diagram Showing Stratigraphy and Potentiometric Surface of the Tertiary Formations, Southeastern Wyoming and Adjacent Part of Colorado. U.S. Geological Survey Miscellaneous Investigations Series Map I-1308.

Crist, M.A., and Borchert, W.B., 1972. The Groundwater System in Southeastern Laramie County, Wyoming. U.S. Geological Survey Open File Report.

Crist, M.A., 1980. Effect of Pumpage on Groundwater Levels as Modeled in Laramie County, Wyoming. U.S. Geological Survey Open File Report 80-1104.

Crist, M.A., 1985. Personal Communication with Hydrologist. U.S. Geological Survey, Water Resources Division, Cheyenne, Wyoming.

Hoxie, D.T., 1977. Digital Model of the Arikaree Aquifer near Wheatland, Southeastern Wyoming. U.S. Geological Survey Open File Report 77-676.

Larson, L.R., 1984. Groundwater Quality in Wyoming. U.S. Geological Survey Water Resources Investigations Report 84-4034.

Louden, K., 1985. Personal Communication with Groundwater Quality Specialist for groundwater quality standards. Wyoming Department of Environmental Quality.

Lowry, M.E., 1966. The White River Formation as an Aquifer in Southeastern Wyoming and Adjacent Parts of Nebraska and Colorado: in U.S. Geological Survey Professional Paper 550-D.

Lowry, M.E., and Crist, M.A., 1967. Geology and Groundwater Resources of Laramie County, Wyoming, with a section on Chemical Quality of Ground-water and of Surface Water by J.R. Tilsta. U.S. Geological Survey Water Supply Paper 1834.

Morgan, A.M., 1946. Progress Report on Geology and Groundwater Resources of the Cheyenne Area, Wyoming. U.S. Geological Survey Open File Report.

Stevens, A.M., 1978. Groundwater Levels in Wyoming, 1977. U.S. Geological Survey Open File Report 78-605.

Theis, C.V., 1941. Preliminary Memorandum on Groundwater Supply of Cheyenne, Wyoming. U.S. Geological Survey Open File Report.

Trelease, F.J., Swartz, T.J., Rechard, P.A., and Burman, R.D., 1970. Consumptive Use of Irrigation Water in Wyoming. Wyoming State Engineer's Office, Wyoming Water Planning Report 5.

Wagner, J., 1985. Personal Communication with Surface Water Quality Specialist for Surface Water Quality Standards. Wyoming Department of Environmental Quality.

U.S. Air Force, 1983. Water Pollution Inventory and Monitoring Summary, November, 1983. Prepared by USAF Hospital, F.E. Warren Air Force Base, Cheyenne, Wyoming.

U.S. Air Force, 1985. Water Pollution Inventory for 1984, Francis E. Warren Air Force Base, Wyoming. Prepared by Chief of Bioenvironmental Engineering, F.E. Warren Air Force Base, Cheyenne, Wyoming.

U.S. Department of Agriculture, Soil Conservation Service, 1985. Personal Communication with District Conservationist for Soil Information on Warren Air Force Base.

U.S. Geological Survey, 1971. Chemical Quality of Water in Southeastern Wyoming, A Basic-Data Report. USGS Water Resources Division in cooperation with the Wyoming Natural Resource Board.

U.S. National Oceanic and Atmospheric Administration, 1974. Climates of the States. U.S. Department of Commerce, V.2, Port Washington, New York.

U.S. Weather Bureau, 1959. Evaporation Maps for the United States. Weather Bureau Technical Paper No. 37.

U.S. Weather Bureau, 1961. Rainfall Frequency Atlas of the United States for Duration from 30 Minutes to 24 Hours and Return Periods from 1 to 100 Years. U.S. Department of Commerce, Technical Paper No. 40.

APPENDIX K

INDEX OF REFERENCES TO POTENTIAL CONTAMINATION SITES AT F. E. WARREN AFB

APPENDIX K
INDEX OF REFERENCES TO POTENTIAL CONTAMINATION SITES
AT F. E. WARREN AFB

Site	References (Page Numbers)
Spill Site No. 4	3, 4, 5, 4-12, 4-13, 4-28, 4-30, 5-1, 5-2, 6-2, 6-4, 6-5, F-4, H-1
Landfill No. 4	4, 5, 6, 4-17, 4-18, 4-19, 4-28, 4-30, 5-2, 5-3, 6-2, 6-5, 6-9, F-4, H-3
Landfill No. 6	4, 5, 6, 4-17, 4-18, 4-19, 4-28, 4-30, 5-2, 5-3, 6-2, 6-5, 6-9, F-5, H-5
Landfill No. 5	4, 5, 6, 4-17, 4-18, 4-19, 4-28, 4-30, 5-2, 5-4, 6-2, 6-5, 6-9, F-6, H-7
Landfill No. 2	4, 5, 6, 4-16, 4-17, 4-18, 4-28, 4-30, 5-2, 5-4, 6-2, 6-5, 6-10, F-5, H-9
Spill Site No. 1	4, 5, 6, 4-11, 4-12, 4-28, 4-30, 5-2, 5-4, 6-2, 6-5, 6-10, F-6, H-11
FPTA No. 2	4, 5, 6, 4-14, 4-15, 4-28, 4-30, 5-2, 5-5, 6-2, 6-6, 6-10, F-7, H-13
Spill Site No. 2	4, 5, 6, 4-11, 4-12, 4-28, 4-30, 5-2, 5-5, 6-2, 6-6, 6-10, F-7, H-15
Acid Dry Well	4, 5, 6, 4-24, 4-25, 4-28, 4-30, 5-2, 5-6, 6-2, 6-6, 6-11, F-8, H-17
FPTA No. 1	4, 5, 6, 4-14, 4-15, 4-28, 4-30, 5-2, 5-6, 6-2, 6-6, 6-11, H-19
Landfill No. 3	4, 5, 6, 4-16, 4-17, 4-18, 4-28, 4-30, 5-2, 5-7, 6-2, 6-6, 6-12, F-9, H-21
Spill Site No. 3	4, 5, 6, 4-12, 4-13, 4-28, 4-30, 5-2, 5-7, 6-2, 6-6, 6-12, H-23
Spill Site No. 5	4, 5, 6, 4-12, 4-14, 4-28, 4-30, 5-2, 5-7, 6-2, 6-7, 6-12, F-9, H-25
Spill Site No. 6	4, 5, 6, 4-12, 4-14, 4-28, 4-30, 5-2, 5-8, 6-2, 6-7, 6-12, F-10, H-27